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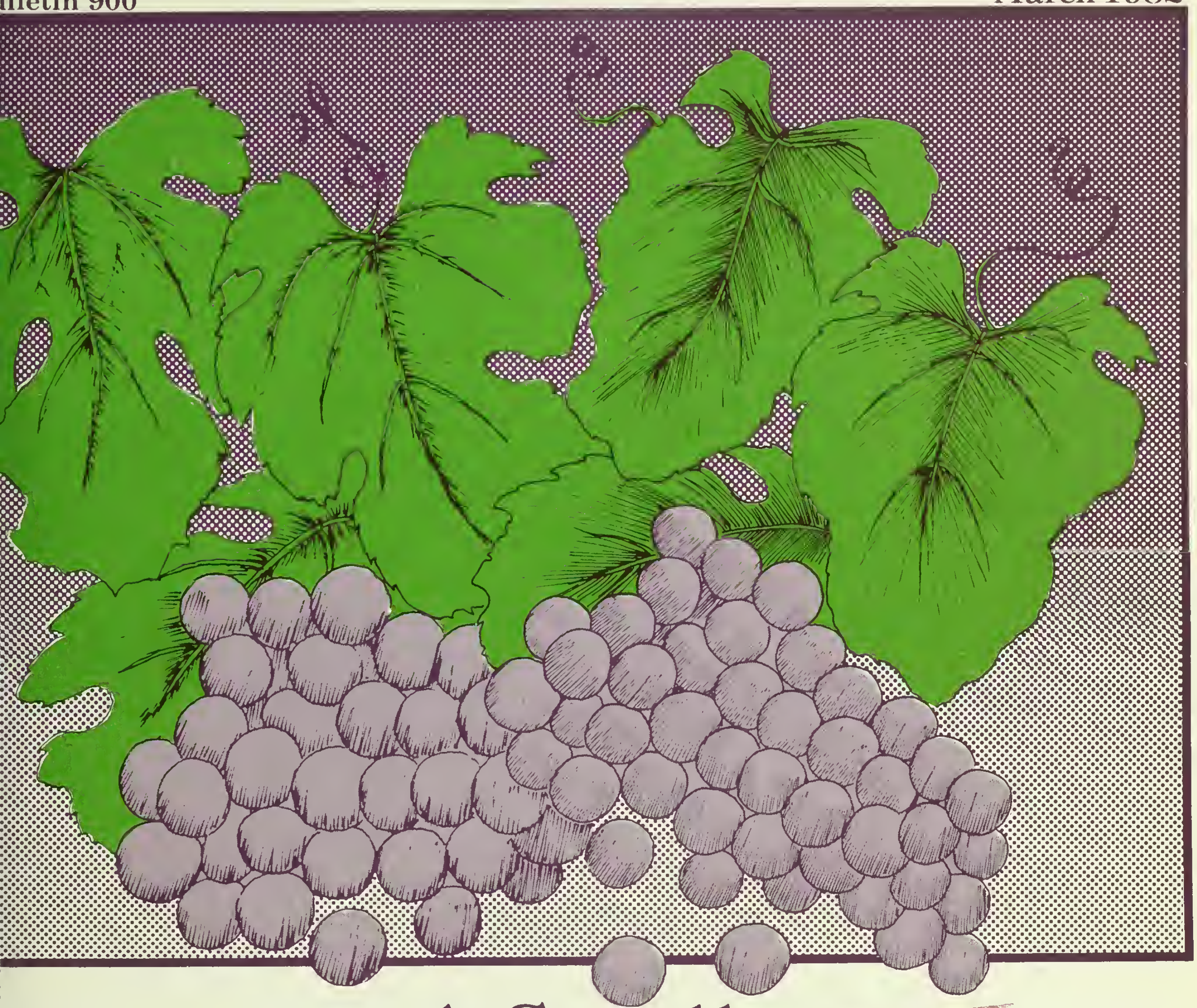

A Small Winery Rinsing Device for Grape-Harvesting Containers

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A Small Winery Rinsing Device for Grape-Harvesting Containers

Fred L. Shuman, Jr., agricultural engineer, MAFES/Mississippi State University Department of Agricultural and Biological Engineering and processing engineer, A. B. McKay Food and Enology Laboratory

A Small Winery Rinsing Device for Grape-Harvesting Containers

Plastic lugs (containers) are used the harvesting of grapes, aches and other fruit in the rious horticultural research ograms in the Mississippi gricultural and Forestry Experient Station. These containers ust be cleaned after each use to inimize contamination. Removal leaves and trash is difficult cause fruit and plant juices on e interior surfaces of the coniners become sticky and essenlly "glue" the material to the side. It is desirable to remove th the debris and the plant and uit juices.

Several cleaning methods were ed in the development of a itable process, and most required nsiderable hand labor and time. is bulletin describes a simple asher developed to reduce the ne and labor normally associated ith cleaning these containers.[1] e device was constructed for eaning containers used in hand rvesting of grapes for processing the A. B. McKay Food and nology Laboratory.

Equipment

A typical lug is the No. 1411 arvest Tainer® manufactured by SCO Plastics, Inc., 300 Garden ty Plaza, Garden City, New rk. This perforated container is out 23 inches (58.4 cm) long by 15 ches (37.8 cm) wide by 7 inches 7.8 cm) deep. The device veloped for rinsing these coniners is shown in Figures 1 and 5.

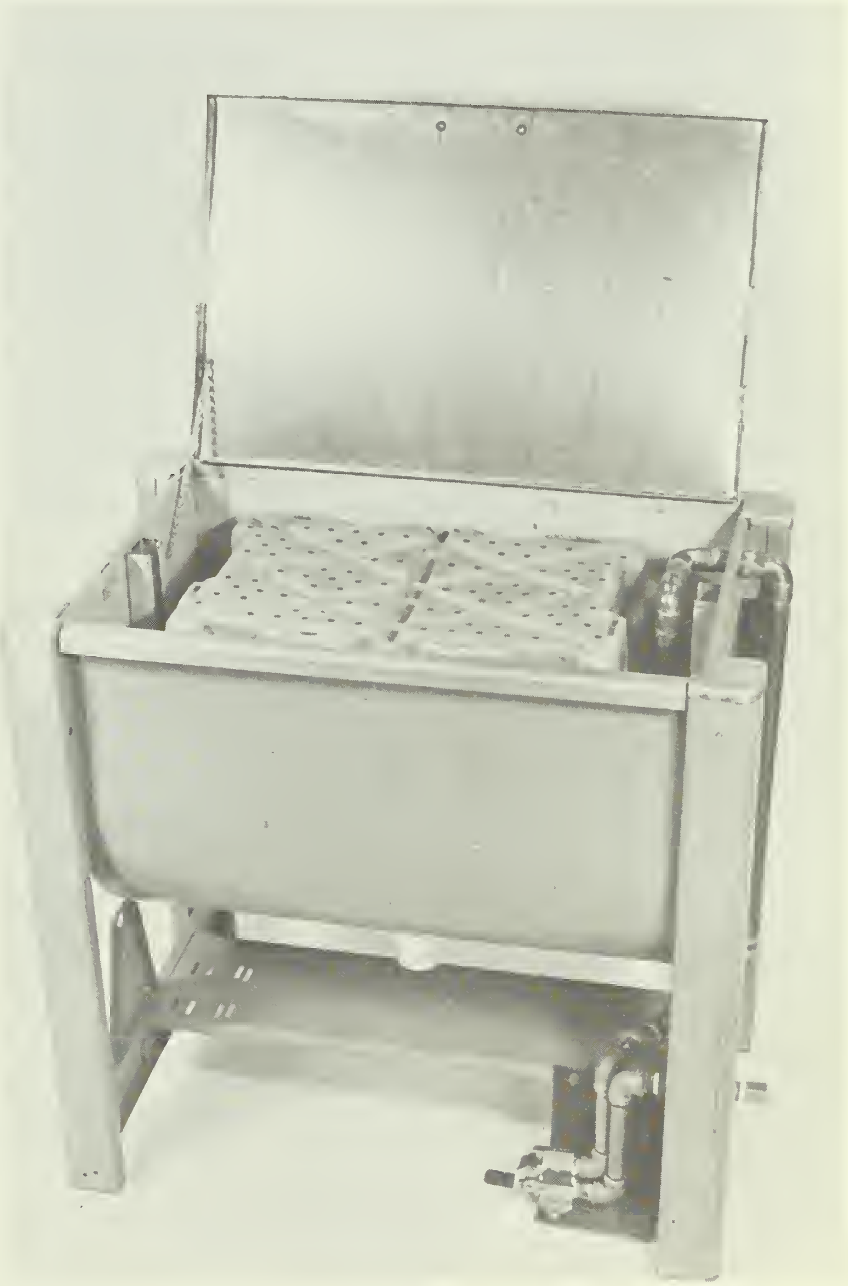

Figure 1. Rinsing device for harvesting containers(with top open).

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[1] *Appreciation is acknowledged to Mr. Anthony Blair, Mr. Cloyd Robinson and Mrs. Neva Wolfe (members of the technical staff of the Agricultural and Biological Engineering Department) for their assistance in the construction and testing of this device and to Mr. Hugh Hudson, student photographer, for the photographic work.*

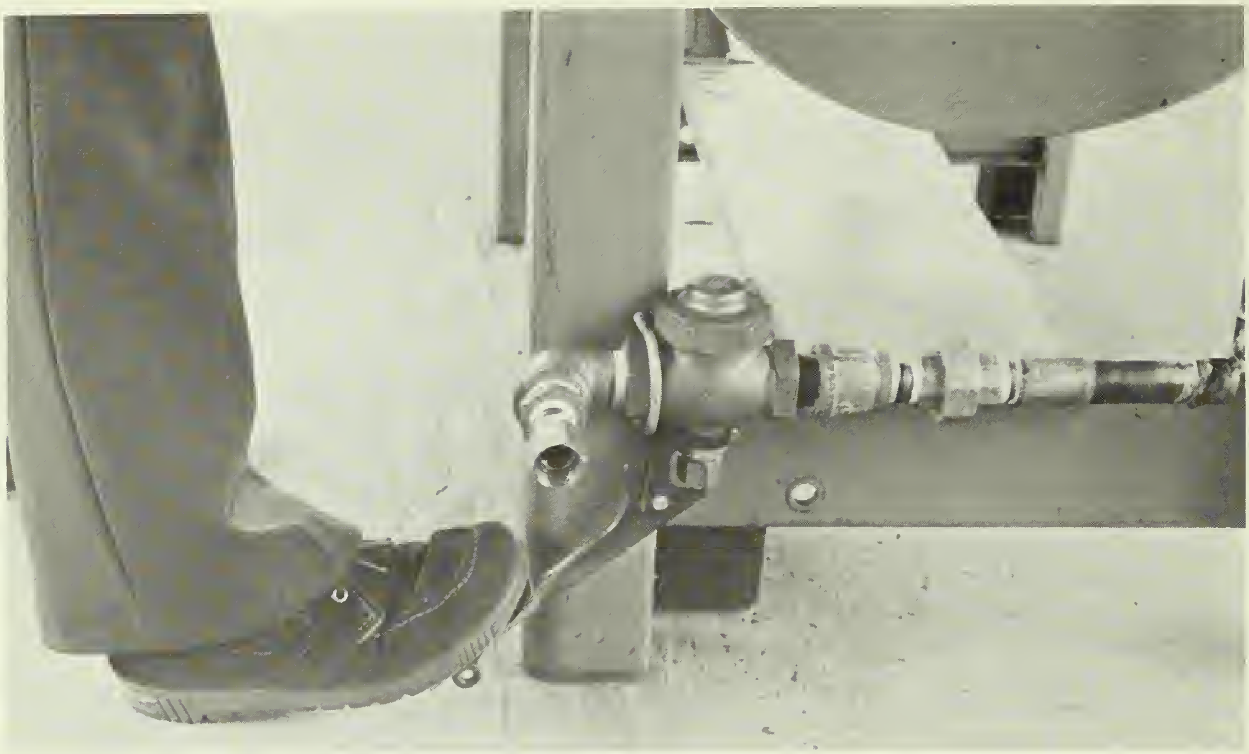


Figure 2. Modified foot-operated valve.

The basic tank and supporting framework can be fabricated from sheet metal and structural steel; however, the tank used in this application was an available photographic print-washing tank equipped with bottom and overflow drains. The components added were a foot-operated valve (Figures 1 and 2---note two possible configurations), a stainless steel hinged top (Figure 1), eight nozzles (Figures 3 and 4) and the required plumbing.

Factors governing the effectiveness of this device were the orientation of the nozzles and the pressure and quantity flow of water. The nozzles used in this application were Tee Jet® TG-10 nozzles manufactured by the Spraying Systems Co., North Avenue and Schmale Road, Wheaton, IL 60187 (Distributed by W. G. Smart Co., Inc., P. O. Drawer 1777, Covington, LA 70433). The nozzles were oriented initially at 90

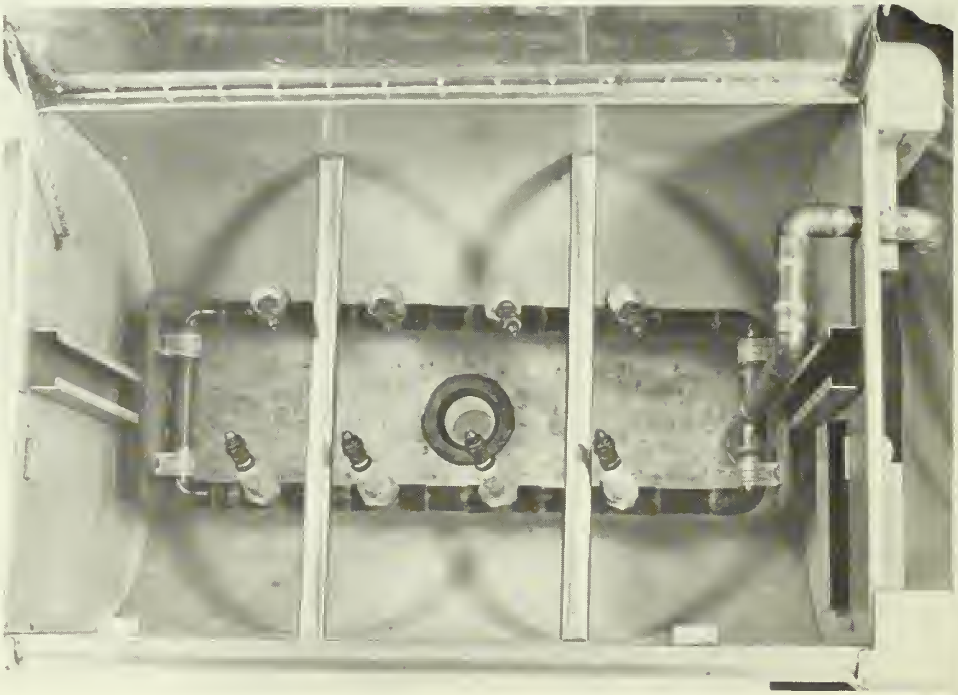


Figure 3. Nozzle location and orientation.

degrees (perpendicular) to the bottom inside surface of the inverted harvesting containers. The water jets from the nozzles removed some of the unwanted materials but also tended to force some of the material against the surface and hold it there. Various angles of orientation were tested in an attempt to inject high velocity water between the debris and the bottom inside surface of the container. The angles that produced the best results with the combination of nozzles, piping, valve and water pressure used in these tests are the ones shown in Figures 3 and 5.

Water flow in the early designs was restricted by the size of the passages (1/2-inch National Pipe Thread) in the original foot-operated valve (Figure 1). A larger valve (Spraying Systems Part No. 3558-1, manufactured by Lunkenheimer Flow Control, Cincinnati, OH 45214 and distributed by W. G. Smart, Inc.) with one-inch NPT inlet and outlet ports was installed to provide the appropriate flow rate and to minimize pressure loss throughout the system (Figure 2). The flow rate was about 18 gallons per minute during the time that the foot pedal was depressed. The inlet pressure from the water line was about 60 pounds per square inch in the tests conducted with the washer.

Standard one-inch copper tubing and fittings and galvanized pipe and fittings were used throughout after installation of the larger valve.

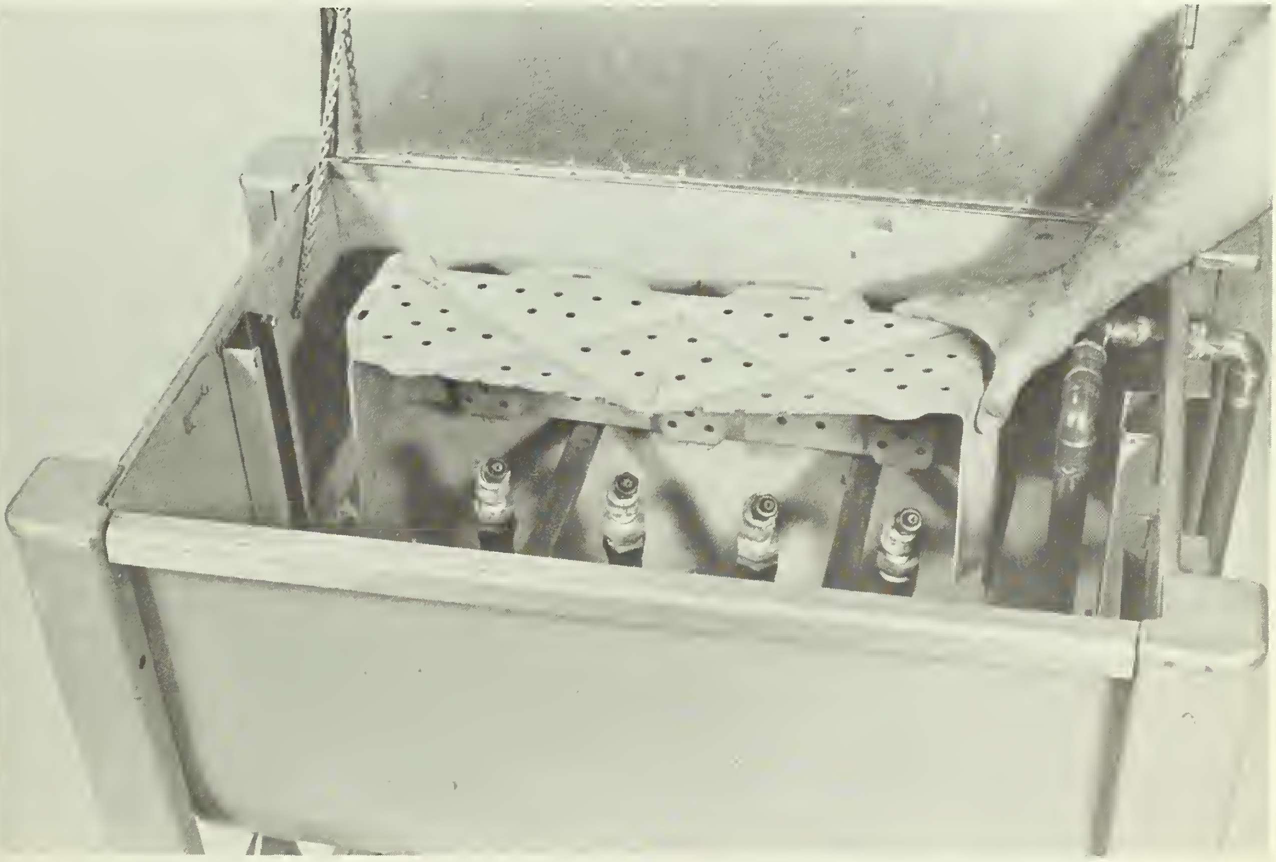
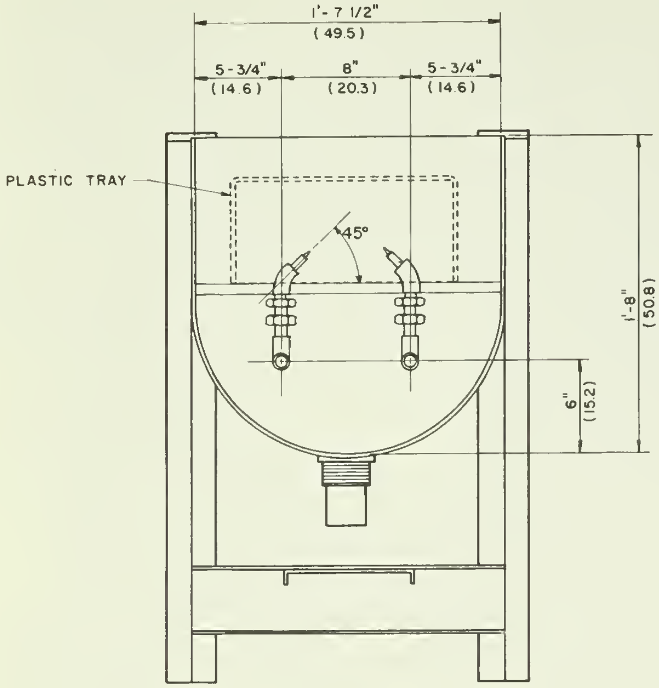
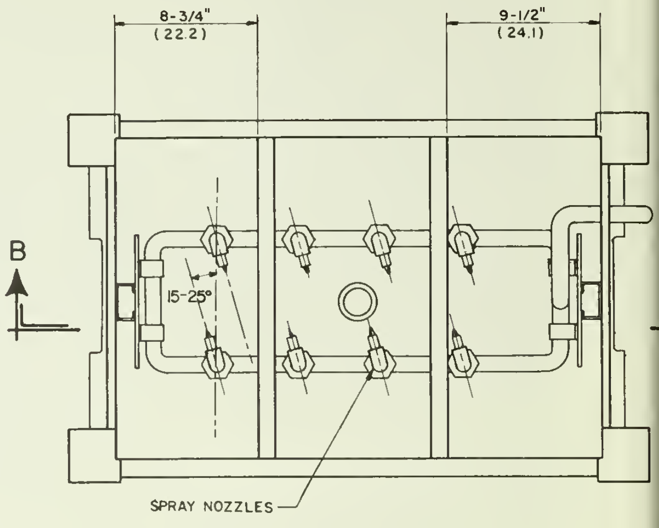


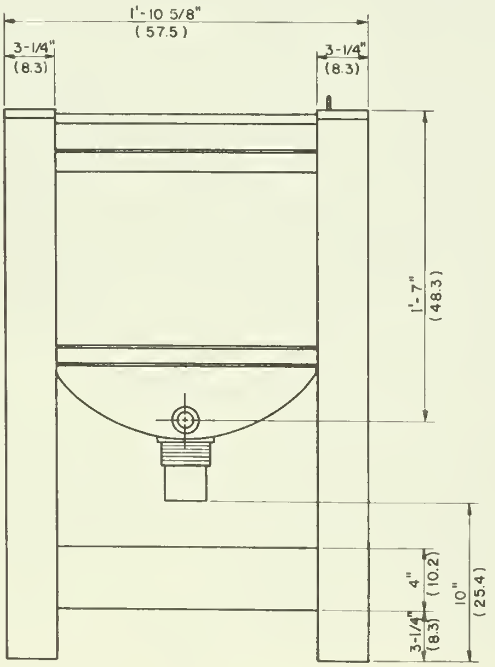
Figure 4. Relationship between nozzles and harvesting container (cutaway).


1'- 7 1/2"
(49.5)
5 - 3/4"
(14.6)
8"
(20.3)
5 - 3/4"
(14.6)
PLASTIC TRAY
45°
1'-8"
(50.8)
6"
(15.2)

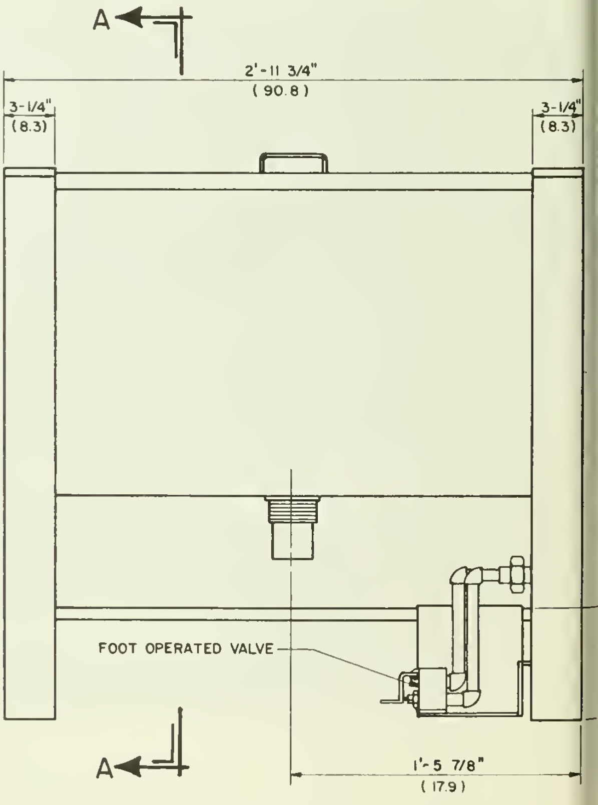
SECTION A-A


8-3/4"
(22.2)
9-1/2"
(24.1)
B
15-25°
SPRAY NOZZLES

TOP VIEW


1'- 10 5/8"
(57.5)
3-1/4"
(8.3)
3-1/4"
(8.3)
1'- 7"
(48.3)
4"
(10.2)
10"
(25.4)
3-1/4"
(8.3)

LEFT SIDE VIEW

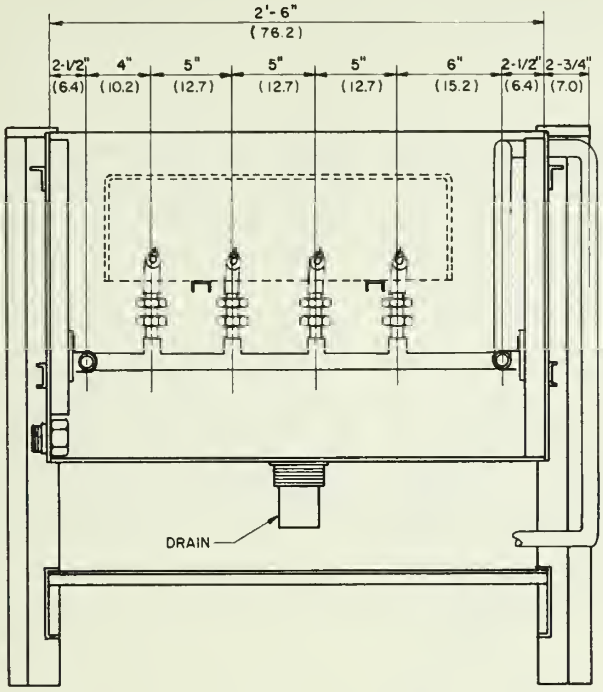

A
2'- 11 3/4"
(90.8)
3-1/4"
(8.3)
3-1/4"
(8.3)
FOOT OPERATED VALVE
A
1'- 5 7/8"
(17.9)

FRONT VIEW

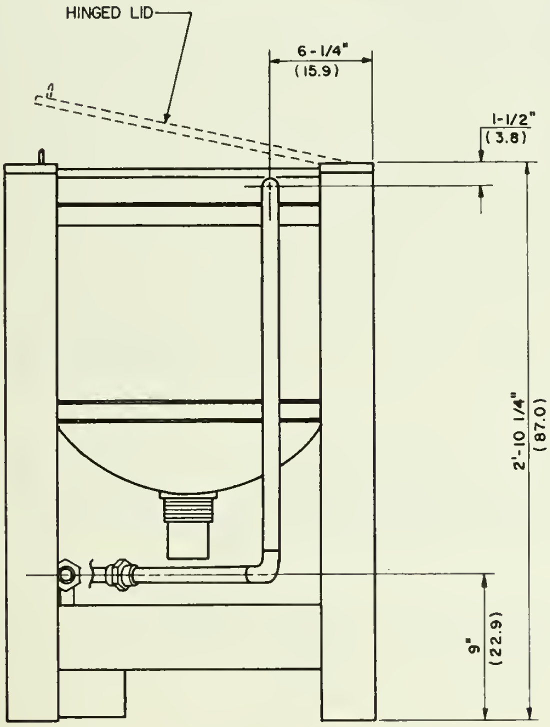
Operating Procedure

The procedure for using the washer is as follows:

1. The container was passed to the person operating the washer as the grapes were emptied from each plastic container. The timing was cordinated with the grape crushing and destemming operation to result in a relatively continuous process.
2. The container was placed upside down in the open washer and was rested on the support rails as shown in Figure 4.
3. The lid of the washer was closed.
4. The operator stepped on the control lever of the foot-operated valve for a few seconds. The length of time required varied with the amount and type of debris to be removed and was varied simply on the basis of operator experience. It was determined that intermittent operation of the foot pedal produced a pulsating jet from the nozzles, which was more effective than continuous flow.
5. The cover was opened.
6. The clean container was removed and was stacked in an inverted position to drain dry.



SECTION B-B



RIGHT SIDE VIEW

Figure 5. Construction drawings for harvesting container rinsing device.

NOTE: ALL DIMENSIONS IN ( ) ARE METRIC, IN CENTIMETERS.

Conclusions and Recommendations

The present design of the washer provides adequate rinsing of debris from the containers, and the nozzle orientation used provides satisfactory results for the operating conditions encountered. The device reduced the amount of time and labor involved in cleaning the containers.

One possible improvement would be the addition of a mechanism to produce a pulsating jet or a rotating spray. It is anticipated that such a modification will be made to the existing unit.

The estimated cost of materials for construction of the washer at current prices (using an angle iron frame and galvanized sheet metal tub, with all other components the same as used in this unit) would be about $160, excluding the cost of the foot-operated valve for which alternatives are available.

The cost of the Lunkenheimer valve used in this application was $138. A similar quick-opening, lever-arm, globe valve (with composition seat) is available for $85 from McMaster-Carr Supply Company, P.O. Box 4355, Chicago, IL 60680. The overall cost of the unit could be reduced considerably by using a simple, manually operated ball valve or butterfly valve (located at a convenient operating point) that costs about $15 (McMaster-Carr). The same type of valve could be modified for operation with a foot pedal and return spring. Total cost of the unit will depend to an extent on the ingenuity and capabilities of the fabricator.

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February 1982

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1981
Mississippi
Cotton Variety Tests

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1981
Mississippi Cotton Variety Tests

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and
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Mississippi Cotton Variety Tests

The Mississippi cotton variety testing program is a continuing evaluation of cotton varieties available from private companies and state agricultural experiment stations. The testing program is conducted to determine the relative performance of available varieties in different environments and distribute the information to producers throughout the state. Tests are conducted at various locations but do not encompass all environments that may be present. However, individual producers may use the results as a guide in selecting the variety or varieties best adapted to their growing conditions.

Several good varieties are well adapted to Mississippi growing conditions, but no single variety is superior for all characteristics because each variety has certain advantages and limitations. A study of the general characteristics along with earliness, storm resistance, disease resistance, grade, fiber quality and seed quality should help in varietal selection.

Yield and earliness of a given variety can be influenced by seed quality, planting date, cultural practices, fertilization, irrigation, weather and weed and insect control. Seed quality is more important with early planting dates where there is a greater probability of cold weather and seedling disease. High seed viability and good seedling vigor help to insure uniform and adequate stands under adverse conditions. Most varieties have about the same number of seed per pound, but a few have very small seed that may require different planter plates to insure the proper plant population.

Maturity becomes more important as one goes from the southern to the northern part of the state, particularily when planting is delayed. Reaction to diseases and insects merits additional consideration because several prevalent diseases can reduce yield of susceptible varieties.

The 1981 cotton variety tests were conducted in four Delta environments (Sumner, Tunica and two sites at Stoneville) and two hill environments (Holly Springs and Mississippi State University).

Each entry was randomized and replicated six times. Yield determinations were based on the weight of cotton harvested from two-row plots. Determinations of lint percentage, boll size, seed index and fiber properties were made from hand-picked samples. Fiber property evaluations were made in the Cotton Fiber Laboratory at Stoneville.

The same 15 varieties were evaluated in all Delta environments and 14 of the 15 were evaluated in the hill environments. Deltapine NSL, Deltapine 62, McNair 220 and HAS 2344 were evaluated for the first time.

The seed planted at each location in 1981 were provided by commercial seed companies, and numbers of seed per pound of acid-delinted seed of the 15 varieties ranged from 4,460 to 5,483. Therefore, planting seed of each variety at the same lbs/acre rate provided the potential for substantial differences in per acre plant populations of the varieties entered.

Results

Delta, 1981

The test at Stoneville on a Bosket very fine sandy loam was planted April 21. Soil moisture was limited, but good stands were established. Plant populations ranged from 44,483 to 59,778 plants per acre and averaged 56,128 plants per acre, and Coker 3131 was the only entry with a plant population less than 50,000 per acre. This test was irrigated on July 16 and was harvested once on September 21. The test matured very early and lint yields ranged from 647 to 886 lbs/acre (Table 1). Fibers were shorter than usual, and micronaire values were relatively low.

The Tunica test was planted April 28 on a Dundee sandy loam and good stands were obtained. The test was harvested on October 12 and lint yields ranged from 650 to 856 lbs/acre (Table 2). Varieties at this location produced cotton with short fiber and high micronaire values. Micronaire values ranged from 4.7 to 5.6, but only the two lowest-producing varieties had micronaire values below 5.0. Fiber strength values at this location were lower than usual.

The test at Sumner on a Dubbs sandy loam was planted April 22 and was harvested September 28. Lint yields were higher than at other test locations and ranged from 986 to 1135 lbs/acre (Table 3). The longest and strongest fiber was produced at this location. Micronaire values were relatively high and ranged from 4.8 to 5.4.

The test at Stoneville on a mixed soil was planted April 15. The test was irrigated July 27 and harvested September 24. Lint yields ranged from 508 to 670 lbs/acre (Table 4). Fiber length values were lower than usual and ranged from 1.02 to 1.14. Micronaire values were relatively high for some varieties and ranged from 4.6 to 5.4.

Table 1. Results of 1981 Cotton Variety Test on a Bosket very fine sandy loam soil at Stoneville.

						FIBER PROPERTIES					
						Length					
Variety	Lint Per acre	Open bolls per acre Aug.19, 1981	Lint percent	Seed index	Boll size grams	2.5%	50%	Strength g/tex	Elongation	Micronaire	Plant height (in.)
DES 422	886	63,969	38.6	10.0	4.85	1.06	.49	18.82	7.0	4.5	39.7
DES 56	882	69,329	36.5	10.4	4.67	1.07	.48	18.36	7.6	4.5	40.3
Stoneville 825	825	39,161	36.9	10.0	4.68	1.09	.50	16.91	6.9	4.4	43.6
Stoneville 213	812	36,326	37.4	10.0	4.86	1.08	.48	18.52	7.9	4.5	41.2
Deltapine NSL	800	44,078	37.5	10.1	5.00	1.05	.49	17.75	8.8	4.6	43.1
McNair 235	796	61,134	36.5	10.5	4.84	1.08	.48	18.51	7.0	4.3	40.5
Deltapine 55	785	41,863	38.0	9.6	4.98	1.08	.49	18.97	7.8	4.1	41.4
McNair 220	785	77,348	35.4	11.1	5.09	1.06	.49	19.36	6.6	4.3	39.1
Deltapine 41	781	41,509	40.1	9.3	4.89	1.07	.49	19.51	7.2	4.3	40.6
Stoneville 506	768	35,396	36.1	10.7	4.90	1.08	.47	19.51	7.7	4.7	39.8
Deltapine 62	757	29,238	36.7	11.2	5.43	1.13	.52	19.51	7.7	4.4	40.4
Coker 315	749	44,920	35.8	11.4	5.44	1.12	.51	19.82	7.5	4.3	40.0
HAS 2344	725	70,171	36.5	10.3	4.62	1.07	.48	18.75	7.7	4.4	40.6
Coker 3131	707	49,439	36.7	11.3	5.29	1.08	.49	18.44	7.3	4.3	41.9
Coker 310	647	39,870	35.2	11.6	5.68	1.10	.50	19.59	6.9	4.3	41.2
LSD .05	64										
C.V.	7.0										

Planted: April 21, 1981
Harvested: September 21, 1981
Irrigated: July 16, 1981

Table 2. Results of 1981 Cotton Variety Test on a Dundee sandy loam soil at Tunica.

					FIBER PROPERTIES				
	LINT PER ACRE				Length				
	Total	Lint percent	Seed index	Boll size grams	2.5%	50%	Strength g/tex	Elongation	Micronaire
Stoneville 213	856	39.7	10.1	5.10	1.01	.45	18.57	7.7	5.6
McNair 235	826	39.9	9.7	4.92	1.04	.50	19.50	6.8	5.5
DES 422	797	40.0	10.0	4.83	1.04	.49	17.71	7.3	5.1
McNair 220	797	38.7	9.9	4.94	1.02	.48	19.11	6.8	5.3
Stoneville 825	795	38.7	10.0	5.02	1.04	.47	17.40	6.7	5.5
Coker 315	789	38.8	10.5	5.71	1.07	.50	19.27	7.8	5.1
DES 56	748	38.6	9.7	4.75	1.06	.51	18.88	7.9	5.0
Deltapine 41	748	42.4	8.2	4.61	1.05	.50	18.57	6.5	5.2
Deltapine NSL	734	39.7	9.5	5.00	1.01	.48	18.33	9.3	5.5
Deltapine 55	725	40.6	9.3	4.77	1.07	.49	17.40	7.1	5.1
Deltapine 62	724	39.6	10.2	5.12	1.06	.49	19.74	7.0	5.4
Coker 3131	723	40.7	10.8	5.31	1.03	.49	17.86	7.6	5.1
Stoneville 506	710	38.9	9.4	4.60	1.06	.48	19.58	8.9	5.0
HAS 2344	651	38.5	9.4	4.56	1.03	.49	18.25	8.9	4.9
Coker 310	650	38.4	10.5	5.99	1.08	.51	20.12	6.6	4.7
LSD .05	94								
C.V.	10.9								

Planted: April 28, 1981
Harvested: October 12, 1981.

Delta Averages

Average lint yield of the 15 cotton varieties grown in the four Delta environments in 1981 ranged from 712 to 862 lbs/acre (Table 5). Average fiber length was shorter than usual, and micronaire values ranged from 4.6 to 5.2.

Average lint yield of the ten varieties that have been tested in 12 Delta environments over a three-year period (1979-81) ranged from 731 to 879 lbs/acre (Table 6). The wide range in characteristics such as yield, maturity, seed size, seed vigor, storm resistance, disease resistance, fiber length, fiber strength and micronaire values permit selection of a variety that will maximize production and profit. Fiber length ranged from 1.10 to 1.16, and micronaire values ranged from 4.5 to 5.0. Seed index (weight of 100 seed) ranged from 9.1 to 11.4 and should be considered in choosing the correct planting plates.

Hill Area, 1981

The test on a Grenada silt loam at Holly Springs was planted May 11 and was harvested twice. Maturity at first harvest on October 12 ranged from 36 to 65% (Table 7). Lint yields ranged from 675 to 954 lbs/acre. Micronaire values were below 5.0 for all varieties except Stoneville 213 and Stoneville 825.

The average lint yield of 11 varieties grown at Holly Springs over a two-year period (1980-81) ranged from 705 to 907 lbs/acre, and maturity at first harvest ranged from 60 to 70% (Table 8). The four earliest-maturing varieties also were the highest yielding. Micronaire values were relatively high, ranging from 4.8 to 5.4.

The Mississippi State test on a Marietta sandy loam was planted April 28 and harvested October 7. Lint yields ranged from 913 to 1148 lbs/acre (Table 9). Micronaire values were relatively low ranging from 4.3 to 5.2, with only three varieties having a micronaire value of 5.0 or above.

The average lint yield of 11 varieties grown at Mississippi State over a two-year period (1980-81) ranged from 1024 to 1144 lbs/acre (Table 10). Micronaire values ranged from 4.7 to 5.4.

Table 3. Results of 1981 Cotton Variety Test on a Dubbs sandy loam soil at Sumner.

	LINT PER ACRE	Lint	Seed	Boll size	FIBER PROPERTIES				
					Length		Strength	Elonga-	Micro-
	Total	percent	index	grams	2.5%	50%	g/tex	tion	naire
DES 422	1135	38.1	11.3	4.96	1.12	.53	21.84	8.6	5.1
Coker 3131	1124	38.6	12.5	5.43	1.10	.51	18.88	7.6	5.1
McNair 235	1121	37.6	12.1	4.62	1.12	.53	19.20	7.7	5.3
McNair 220	1109	36.6	12.2	4.81	1.13	.55	21.76	6.9	5.3
Deltapine 41	1109	40.3	9.5	4.87	1.10	.50	19.44	7.6	5.0
DES 56	1098	37.2	10.9	5.08	1.12	.53	22.00	8.6	5.0
Coker 315	1098	37.2	12.2	5.37	1.16	.55	21.28	6.3	5.0
Stoneville 825	1094	37.6	11.6	5.15	1.09	.50	18.96	7.1	5.4
Deltapine 62	1091	37.3	11.9	5.78	1.17	.55	20.88	8.5	5.4
Stoneville 213	1088	37.5	11.6	5.27	1.09	.51	19.68	7.9	5.4
Deltapine NSL	1021	38.6	10.8	5.18	1.07	.52	20.48	9.7	5.4
HAS 2344	1014	37.0	10.8	4.66	1.09	.49	19.36	8.5	4.8
Stoneville 506	1003	36.2	11.9	5.20	1.13	.53	19.92	7.9	5.2
Coker 310	993	36.6	12.0	5.25	1.18	.56	22.88	7.0	4.9
Deltapine 55	986	38.3	10.8	4.99	1.10	.50	19.52	8.5	5.0
LSD .05	100								
C.V.	8.0								

Planted: April 22, 1981
Harvested: September 28, 1981

Table 4. Results of 1981 Cotton Variety Test on a mixed soil at Stoneville.

	LINT PER ACRE			Boll	FIBER PROPERTIES				
	Total	Lint percent	Seed index	size grams	Length 2.5%	Length 50%	Strength g/tex	Elonga-tion	Micro-naire
Deltapine 55	670	40.9	9.6	4.50	1.06	.48	20.51	9.4	5.1
Stoneville 506	642	37.3	11.0	4.80	1.11	.51	19.46	9.7	5.2
DES 422	631	39.1	9.9	4.17	1.07	.49	20.16	7.5	4.8
Stoneville 825	611	39.5	10.3	4.35	1.06	.49	19.32	7.1	5.4
DES 56	607	37.5	10.7	4.43	1.08	.48	21.64	8.4	5.0
Stoneville 213	601	37.7	10.2	4.58	1.10	.50	20.65	9.6	4.9
Deltapine 41	594	41.7	8.8	4.24	1.06	.46	21.01	7.8	5.2
McNair 235	588	37.5	10.5	4.04	1.09	.51	22.14	7.8	4.8
Deltapine NSL	571	38.5	10.0	4.61	1.02	.48	20.59	9.7	5.4
Deltapine 62	559	36.2	11.0	4.75	1.13	.51	22.70	7.8	4.9
McNair 220	558	36.3	10.9	4.62	1.10	.51	22.28	7.6	4.9
Coker 310	557	36.3	11.8	5.38	1.14	.52	22.77	8.3	4.6
Coker 315	543	37.4	11.0	4.69	1.10	.50	20.37	7.8	4.9
HAS 2344	541	36.2	9.9	5.34	1.09	.49	20.58	9.3	4.6
Coker 3131	508	38.4	11.8	4.73	1.06	.50	19.88	9.3	4.9
LSD .05	101								
C.V.	15.6								

Planted: April 15, 1981
Harvested: September 24, 1981
Irrigated: July 27, 1981

Table 5. Average performance of 15 cotton varieties in four Delta environments[1/] in 1981.

	LINT PER ACRE			Boll	FIBER PROPERTIES				
	Total	Lint percent	Seed index	size grams	Length 2.5%	Length 50%	Strength g/tex	Elonga-tion	Micro-naire
DES 422	862	38.9	10.3	4.70	1.07	.50	19.63	7.3	4.9
Stoneville 213	839	38.1	10.5	4.95	1.07	.48	19.35	8.3	5.1
DES 56	834	37.5	10.5	4.73	1.08	.50	20.22	8.1	4.9
McNair 235	833	37.9	10.7	4.60	1.08	.50	19.84	7.3	5.0
Stoneville 825	831	38.2	10.5	4.80	1.07	.49	18.14	6.9	5.2
McNair 220	812	36.7	11.0	4.86	1.08	.51	20.63	7.0	5.0
Deltapine 41	808	41.1	8.9	4.65	1.07	.49	19.63	7.3	4.9
Coker 315	795	37.3	11.3	5.30	1.11	.51	20.18	7.4	4.8
Deltapine 55	791	39.4	9.8	4.81	1.08	.49	19.10	8.2	4.8
Deltapine 62	783	37.4	11.1	5.27	1.12	.52	20.71	7.7	5.0
Deltapine NSL	782	38.6	10.1	4.95	1.04	.49	19.29	9.4	5.2
Stoneville 506	781	37.1	10.7	4.87	1.09	.50	19.62	8.5	5.0
Coker 3131	765	38.6	11.6	5.19	1.07	.50	18.77	7.9	4.8
HAS 2344	733	37.1	10.1	4.80	1.07	.49	19.23	8.6	4.7
Coker 310	712	36.6	11.5	5.57	1.12	.52	21.34	7.2	4.6

[1/] Four environments - Stoneville 2, Tunica 1, Sumner 1.

Table 6. Performance of 10 cotton varieties in 12 Delta environments[1/], 1979-1981 average.

	LINT PER ACRE	Lint	Seed	Boll size	FIBER PROPERTIES				
					Length		Strength	Elonga-	Micro-
	Total	percent	index	grams	2.5%	50%	g/tex	tion	naire
DES 422	879	38.9	10.2	4.70	1.11	.55	19.33	7.2	4.6
Stoneville 825	859	38.1	10.7	4.78	1.10	.53	18.70	6.4	5.0
DES 56	854	37.8	10.6	4.78	1.12	.55	20.48	7.7	4.7
Deltapine 41	836	41.3	9.1	4.71	1.11	.54	19.72	7.1	4.7
Stoneville 506	818	37.0	10.9	4.84	1.12	.54	19.52	7.9	4.8
Stoneville 213	815	37.9	10.6	4.98	1.11	.54	19.27	7.8	5.0
McNair 235	810	37.9	10.7	4.78	1.11	.55	20.30	6.7	4.8
Deltapine 55	799	39.5	9.9	4.89	1.11	.54	18.91	7.5	4.6
Coker 315	779	38.0	11.0	5.20	1.16	.57	20.90	6.8	4.6
Coker 310	731	36.8	11.4	5.48	1.16	.57	20.98	6.8	4.5
LSD .05	45								
C.V.	6.7								

[1/] Twelve environments - Stoneville 6, Tunica 3, Sumner 3.

Table 7. Results of 1981 Cotton Variety Test on a Grenada silt loam soil at Holly Springs.

	LINT PER ACRE			Lint	Seed	Boll size	FIBER PROPERTIES				
							Length		Strength	Elonga-	Micro-
	Total	First pick	Percent first pick	percent	index	grams	2.5%	50%	g/tex	tion	naire
DES 422	954	556	58	38.7	9.8	5.50	1.04	.49	20.23	9.2	4.6
McNair 235	927	512	55	37.7	10.1	6.14	1.03	.51	20.66	8.1	4.8
DES 56	873	505	58	37.1	10.2	5.22	1.06	.51	19.87	10.1	4.9
Stoneville 506	871	464	53	36.4	9.5	4.99	1.09	.52	20.37	8.7	4.4
Deltapine NSL	865	418	48	36.7	9.4	5.06	1.05	.51	19.59	10.4	4.3
Stoneville 825	811	398	49	36.1	10.1	5.59	1.03	.48	20.37	7.4	5.1
Stoneville 213	779	325	42	37.0	10.6	6.02	1.04	.50	20.30	8.9	5.0
Deltapine 55	769	385	50	39.8	8.9	5.05	1.07	.49	20.38	9.6	4.3
Deltapine 41	763	356	47	39.9	8.8	4.86	1.07	.51	21.52	9.4	4.7
HAS 2344	758	490	65	37.0	9.9	4.95	1.03	.47	20.66	10.6	4.4
Coker 3131	750	390	52	39.7	10.7	5.61	1.05	.51	21.37	9.0	4.6
Coker 310	686	335	49	38.0	10.5	6.12	1.09	.52	22.88	6.6	4.5
Deltapine 62	683	246	36	34.5	10.7	5.50	1.11	.54	22.23	10.1	4.2
Coker 315	675	294	43	37.4	9.9	5.80	1.08	.50	22.52	8.6	4.6
LSD .05	70										
C.V.	7.6										

Planted: May 11, 1981
Harvested: October 12 and 30, 1981

Table 8. Performance of eleven cotton varieties at Holly Springs, 1980-81 average.

	LINT PER ACRE					FIBER PROPERTIES				
					Boll	Length				
	Total	Percent first pick	Lint percent	Seed index	size grams	2.5%	50%	Strength g/tex	Elongation	Micronaire
McNair 235	907	69	38.2	10.2	5.48	1.07	.52	21.26	6.8	4.9
DES 422	851	70	39.2	9.9	5.25	1.07	.51	20.27	7.2	4.8
DES 56	810	70	38.0	10.3	4.80	1.10	.54	20.37	8.4	5.0
Stoneville 506	789	68	36.4	10.6	4.80	1.11	.53	20.51	7.5	4.9
Stoneville 825	786	65	37.5	10.3	5.22	1.06	.50	19.91	6.2	5.4
Stoneville 213	762	60	37.9	10.6	5.42	1.07	.52	20.34	8.0	5.3
Deltapine 41	762	62	41.2	9.1	4.67	1.09	.52	21.05	7.7	5.2
Deltapine 55	729	67	39.7	9.5	4.88	1.09	.51	20.37	7.9	4.8
Coker 3131	729	63	40.4	11.2	5.04	1.08	.52	20.87	7.9	4.9
Coker 315	724	62	38.3	10.4	5.35	1.11	.53	21.94	7.1	4.9
Coker 310	705	63	38.3	10.8	5.58	1.11	.53	21.48	6.0	4.8

Table 9. Results of 1981 Cotton Variety Test on a Marietta sandy loam soil at Mississippi State University.

				FIBER PROPERTIES				
	LINT PER ACRE	Lint	Boll size	Length				
	Total	percent	grams	2.5%	50%	Strength g/tex	Elongation	Micronaire
Deltapine 41	1148	43.1	5.1	1.09	.51	21.45	8.2	4.9
McNair 235	1122	40.7	5.0	1.08	.50	21.02	8.3	4.3
Stoneville 213	1117	39.3	5.3	1.08	.50	20.95	8.8	4.8
Deltapine 55	1112	41.1	5.1	1.11	.49	20.81	8.0	4.6
Stoneville 825	1104	41.0	4.8	1.07	.47	19.45	7.9	5.2
Deltapine 62	1088	39.4	5.4	1.11	.50	22.09	9.0	4.8
Coker 315	1079	38.9	5.5	1.08	.47	22.64	7.5	4.4
Coker 310	1067	39.6	5.5	1.12	.49	22.41	8.4	4.4
Coker 3131	1059	40.6	4.5	1.07	.48	21.09	8.0	4.4
Deltapine-NSL	1022	39.6	5.3	1.04	.47	20.50	10.2	5.2
DES 56	1019	39.7	4.8	1.07	.48	21.02	8.0	4.7
DES 422	1007	40.5	5.0	1.07	.48	20.00	7.6	4.4
Stoneville 506	1001	39.4	4.8	1.05	.45	20.52	9.4	5.0
HAS 2344	913	38.8	4.6	1.09	.48	21.09	9.0	4.4
LSD .05	101							
C.V.	8.2							

Planted: April 28, 1981
Harvested: October 7, 1981

Table 10. Performance of eleven cotton varieties at Mississippi State University, 1980-81 average.

			Boll	FIBER PROPERTIES				
	LINT PER ACRE	Lint	size	Length		Strength	Elongation	Micronaire
	Total	percent	grams	2.5%	50%	g/tex		
McNair 235	1144	39.6	5.1	1.11	.53	21.83	7.7	4.8
Deltapine 41	1143	41.6	5.0	1.11	.53	22.25	7.9	5.2
Coker 310	1117	38.7	5.4	1.15	.53	23.02	7.5	4.7
Coker 315	1116	39.1	5.3	1.11	.51	22.23	7.1	4.8
Deltapine 55	1114	40.1	5.2	1.13	.52	20.73	7.6	5.1
Stoneville 213	1112	37.9	5.5	1.12	.53	20.92	8.4	5.2
Coker 3131	1108	40.5	5.2	1.09	.51	21.24	7.7	4.8
Stoneville 825	1084	39.1	5.0	1.12	.51	20.60	7.1	5.4
Stoneville 506	1051	37.9	5.0	1.12	.51	21.61	8.9	5.1
DES 422	1027	39.0	5.1	1.11	.52	21.17	7.6	4.7
DES 56	1024	38.0	4.7	1.13	.53	21.27	7.9	4.9

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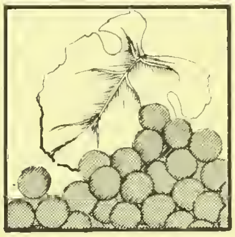
Bulletin 902 April 1982

Making Bottle-Fermented Sparkling Wine at Home



B. J. Stojanovic

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Making Bottle-Fermented Sparkling Wine at Home

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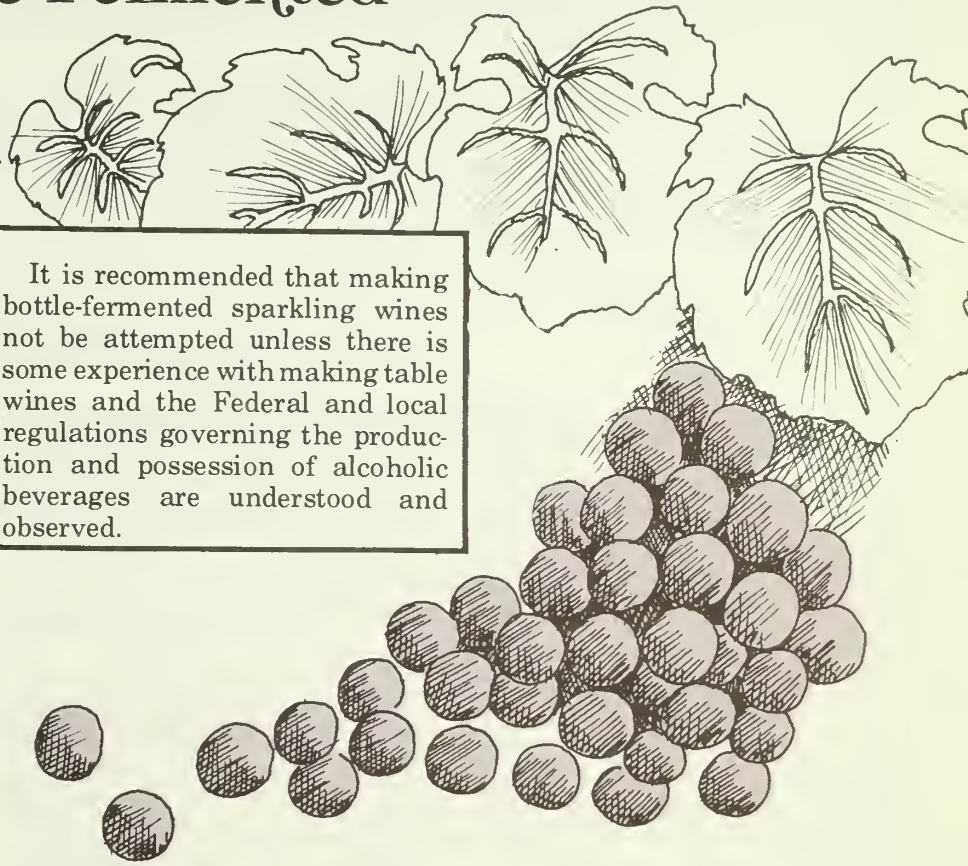
Making Bottle-Fermented Sparkling Wine at Home

Sparkling wine made by the bottle-fermented method or Methode Champenoise (as used in the French province of Champagne) is a wine that contains more than 0.392 grams (g) of carbon dioxide (CO_2) per 100 milliliters (ml). This amount of CO_2 is about 15 pounds per square inch (psi) or 1.0 atmosphere of CO_2 pressure at 15.56°C(2). Most sparkling wines contain 60-80 psi when finished.

All equipment used in making bottle-fermented sparkling wine should be cleaned thoroughly with hot water, steam, trisodium phosphate or sodium carbonate. (*Never use soap or detergents*). Accurate records of all operations should be maintained.

The steps in making sparkling wines are as follow:

It is recommended that making bottle-fermented sparkling wines not be attempted unless there is some experience with making table wines and the Federal and local regulations governing the production and possession of alcoholic beverages are understood and observed.



Step 1. Preparation of Blend or Cuvée

The sparkling wines are made from blends or cuvées of two, three, four or more wines. Wines to be used for making a sparkling wine should be made from grapes selected for that purpose and preferably from the free-run juice. Only well-made, stabilized, fined and filter-polished still white, red and rose wines should be used for the preparation of a blend or cuvée. The purpose of blending is to obtain certain flavor and aroma qualities, chemical balance and other desired characteristics in the finished product.

The white cuvée should be of light straw to pale yellow color and light in body, with no noticeable defects or off-flavors and practically no residual sugar (dry wine). The alcohol content should be 9.5 to 11.5% by volume. The free sulfur dioxide (SO_2) content should be 0 to 10 parts per million (ppm), with total acidity between 0.7 and 0.9 g/100 ml and pH between 2.9 and 3.5. The cuvée should be free of preservatives (1,2).

About 1% of the cuvée should be withdrawn and set aside for use in finishing the sparkling wine (6).

Step 2. Adjustment of Alcohol Content and Acidity of the Cuvée

The usual content of alcohol (11 to 12%) in dry wines can inhibit yeast somewhat and can prevent refermentation of the cuvée or cause fermentation to proceed extremely slowly. Therefore, dilution to lower the alcohol content to about 10.0 to 10.5% by volume is customary. Suppose that 100 gallons (378.5 liters) of a cuvée with 12% alcohol by volume is to be diluted to 10.5% alcohol content. A formula that can be used is

$$(V + W)\, X = (W)\, (Y), \text{ where}$$

V = Volume of water to be added to the cuvée

W = Volume of cuvée to be diluted

X = Percentage of alcohol (by volume) desired in diluted cuvée

Y = Percentage of alcohol (by volume) in the cuvée to be diluted.

Using the above example it follows that

$$(V + 100)\, 10.5 = (100)\, (12)$$

$$10.5V + 1050 = 1200$$

$$V = \frac{1200 - 1050}{10.5} = 14.3 \text{ gals of water}$$

to be added, or 54.1 liters.

Sparkling wines are invariably more acid than ordinary dry tabl wines because of CO_2 production As a general practice, the wine intended for use as a cuvée shoul be adjusted during preparation o the cuvée. Acidity that is too low o too high must be corrected befor the cuvée is dispensed int champagne-type bottles fo refermentation.

Step 3. Addition of Sugar

The cuvée must be dry. Residual fermentable sugar must be entered in the calculation of initial sugar content of the cuvée. As a general rule, 0.5 ounces of sugar per gallon (4 grams of sugar per liter) will produce 1 atmosphere of CO_2 pressure or 15 psi. Sparkling wines usually contain 5 to 6 atmospheres or 70 to 90 pounds psi pressure. Therefore, sugar is added at 2 to 2.5 ounces per gallon (16 to 20 grams per liter).

Sucrose or cane sugar is the sugar of choice. After thorough mixing to dissolve the sugar, degrees Brix are checked with a narrow-range hydrometer (-0.5 to +0.5 Brix). For practical purposes, the sugar content should not exceed +0.5 Brix.

Step 4. Addition of Energizers

Energizers serve as nutrients and/or growth substances. Of the essential nutrients required, nitrogen is most frequently in low supply or may be lacking. It may be added to the cuvée as diammonium phosphate, at a rate of 0.5 grams per liter or 4 pounds per 1,000 gallons (4). A source of vitamin B_2 also is added at a rate of 0.05 grams per liter or 0.4 pound per 1,000 gallons of cuvée. A commercial product sold under the trade name of Yeastex® can be used instead, because it serves as a source of nitrogen and vitamins.

Step 5. Addition of Yeast Inoculum

Several champagne yeast strains are commercially available. The yeast must be selected carefully for the purpose of refermentation. It must have the ability to ferment under the conditions in the cuvée (10.5% alcohol) and must be able to produce granular sediment of yeast cells at the completion of fermentation. The yeast starter is grown in the usual fashion in some of the cuvée. When the starter cells are growing actively, the yeast inoculum is added to the cuvée at the rate of 2 to 3% by volume (1).

Step 6. Bottling

The cuvée is agitated to prevent settling of the yeast and is filled into 750 ml-capacity champagne bottles. The bottles are sealed with cork-lined crown caps of best quality. They are capped using a specially designed capper. Champagne bottles are manufactured of heavy glass and have a push-up or punt at the bottom. This provides added strength of the bottle (1). If the temperature is too high, fermentation too fast, sugar content too high or bottles are scratched or defective, bursting of bottles may occur and losses will be excessive. *The bottles should not be re-used.*

Step 7. Fermentation in the Bottle or "Tirage"

The bottles are stacked horizon-ally (binned on their sides) in a ellar kept at between 15.5 and 21.1^0 C (60 to 70^0 F), and the contents are llowed to ferment. The yeast onverts sugar into CO_2 and ethyl lcohol, but, unlike the fermenta-ion of still wine, the CO_2 cannot scape and is dissolved in the wine. As a result, considerable pressure (80 to 100 psi) is created in the bottles. The fermentation is rather slow and may proceed for months. More flavor and bouquet develop and permeate the wine the longer the wine is kept in tirage. The ensuing flavor stems from the autolysis of a thin film of yeast cells found on the walls of the bottle, followed by intricate biochemical transformations within the contents of the bottle. Completion of fermentation can be ascertained accurately by correct measurement of the atmospheres of CO_2 pressure.

Step 8. Riddling or "Remuage"

The wine is cleared and riddled at east three months (preferably six nonths) when fermentation is omplete and the wine has aged. In France, riddling is called remuage," meaning "moving", and the individual performing this process is called a riddler. In iddling, the yeast is settled onto he cork of the crown cap. The purpose is to collect the sediment nto a compact mass on the cap.

In this step, bottles are placed neck down at about an 80° angle (3) in 2.5″ (6.3 cm) diameter holes spaced about 6″ (15 cm) apart in specially designed racks ("A" frames). A protective face and throat shield should be worn by the riddler, along with protection for hands, arms and legs in case of bottle breakage.

To dislodge the sediment from the walls, the bottle is given a short sharp turn (usually 1/4 of a turn in clockwise direction on days 1, 3 5--- and in the opposite direction on days 2, 4 6---) and is dropped back into the rack with a jolt. Different techniques are used by different riddlers. The riddling may be finished in a week (if the wine is easily clarified) or may require a month or longer. Clarity is established by visual inspection (often with the aid of a light source held behind the bottle) of several bottles selected at random.

Step 9. Disgorging

The bottles are disgorged when he wine is "clear". This is the emoval of sediment (deposited on he crown cap) without loss of wine. Stated otherwise, disgorging is the reezing of an ice plug in the neck of he bottle with a brine solution or y other methods (4) and removal f the crown cap to allow the ice to ush the yeast sediment out ahead f it, thus clarifying the contents of he bottle.

The bottles are removed carefully neck down) from the riddling acks before disgorging and are tored in a chiller where they are eld at about -4°C (25°F) for several ays to several weeks. This holding eriod serves to eliminate tartrates nd to assure CO_2 retention by the vine. Red wines often are allowed a longer cold-holding period than are the whites.

After chilling, the bottles are placed (neck down) in a prepared solution of coarse salt and crushed ice or in a mechanically cooled refrigerant (diluted ethyl alcohol, glycol, etc.) so that the solution reaches about one inch (2.5 cm) up the neck of the inverted bottles (4). Contents of the neck freeze, and the sediment forms a solid plug of ice. The freezing time will be between 10 to 15 minutes at a temperature of -15°C (5°F). Disgorging should be done with care to guard against abrupt temperature changes that may crack the bottles.

The bottle then is removed and turned upright at about a 45° angle, and the cap is removed with a cap opener. The ice and sediment with it are pushed out by the CO_2 pressure. To prevent the ice plug from being discharged into open space, a "window" can be cut in the side of a container so that the neck of the bottle can be inserted in it. The ice plug and sediment are then trapped in the container when discharged from the bottle.

Properly performed, this operation leaves the bottle and its remaining contents brilliantly clear. As some CO_2 and wine are lost by this operation, it is recommended that the thumb be placed over the mouth of the bottle to minimize loss and that the bottle be placed gently on a table.

Step 10. "Dosage"

Dosage is the addition of syrup to adjust the sweetness of the wine and restore the contents lost during disgorging. Most people seem to prefer dry sparkling wine, but such wines may taste unpleasantly tart without a little sugar. How much sugar to add depends on the preference of the winemaker.

The dosage syrup usually consists of about 60 grams of cane sugar (sucrose) in 100 ml of a mixture of 90 parts of the original cuvée (or a compatible well-aged, high quality table wine) and 10 parts of high-proof, high-quality brandy (1). The practice of adding brandy is used only infrequently today because the natural grape flavors developed with sound fermentation and aging techniques are preferred. Dosage also must contain SO_2 preservative calculated to raise the SO_2 content in the sparkling wine to about 50 ppm. The usual volume of dosage is 50 ml. However, if this does not bring the volume in the bottle to 750 ml, the wine from another bottl without dosage is used to make u the deficiency (for "topping up").

Dosage is administered with special machine that provide establishment of a closed system and an equilibrium before furthe processing. Adding dosage b hand also is possible if extrem caution is practiced; otherwise excessive effervescence may ensue and large losses may be experien ed.

Step 11. Closure, Wire Hooding and Capsuling

Finished sparkling wines are corked and wire hooded. Corking involves using natural corks (preferably laminated) or plastic stoppers. Natural corks need to be softened by presoaking in warm water 40 to 45 minutes or in glycerol (about 2%) held at 26.6°C (80°F) for about one hour. A specially made machine must be used to drive the corks into the bottles. A cork about 1.22″(31 mm) diameter by 1.89″ (48 mm) long is driven about 0.83″ (21 mm) into a bottle with a mouth diameter of 0.63″ to 0.67″ (16.3 to 16.7 mm) (2). Recently developed plastic stoppers of high quality are applied by hand, using a mallet to drive them into the bottle. They do not require presoaking and are ordinarily leak tight.

Cork and plastic stoppers are further secured by putting appropriate wire hoods over them. The loop of the hood is fitted under the "ridge" of the bottle, and the two ends are brought together and twisted until the loop fits snugly against the neck of the bottle.

The finished bottles are rinsed outside by hand wiping, rotating brushes or water sprays and ar stored horizontally for a brie period (2 to 3 months) at a relative ly constant temperature of 10° t 15.5° C (50 to 60° F) to set the cor into the bottle, to allow the dosag liquor to "marry" with the win and to detect the leaker bottles Further aging appears to be of n great advantage. The bottles the are inspected, labeled, foiled an flounced, and the wine is ready t be served.

Suggested Equipment and Supplies

1. *Wine hydrometer* -0.5 to +0.5 Brix
2. *Potassium metabisulfite*
3. *Reagents, glassware and other equipment* needed for determination of pH, total acid, volatile acid, free and total SO_2 , alcohol, extract, etc.
4. *Yeast.* Active dry yeast is preferred. It should contain about 20 to 30 billion live yeast cells per gram. Most common strains are *Saccharomyces bayanus* ("Pasteur" - U.C. Davis Enology # 595; and "California Champagne" - U.C. Davis Enology # 505), "Ay Champagne" - U. C. Davis Enology # 503 and "BYL" - Berkeley Yeast Laboratory (2).
5. *Yeast nutrients(s)*, vitamins, growth factors, etc.
6. *Cane sugar*
7. *"A" frame(s)*
8. *Champagne bottles.* "Stock" 750 ml. bottles 32 to 35 ounces in weight, designed to withstand pressures of seven gas volumes at 50°C or about 220 pounds per square inch gauge (psig). Color of the bottles is either champagne green (dark green) or emerald green. Th finish of the neck should a commodate a crown cap, natural cork and/or a plasti stopper. Bottles also shoul have a special surface coatin that helps to protect the during handling (2).
9. *Crown caps* usually are 26 m in diameter and are coate tinplate or stainless steel. Ca liners are ground cork wit vinyl disks or elastomer plasti (2).
10. *Corks.* Natural cork preferred. Corks are about

mm in diameter and about 48 mm in height. Upper part of cork is composed of cork particles, 2 to 6 mm in size, bonded together with a polypropylene resin. Laminated corks have two or three disks, about 6 mm thick, which are bonded to the bottom of the cork. Most corks have a light band of paraffin about 18 mm wide around the body. Corks are sold in plastic bags of 1,000 to 5,000 (2).

11. *Plastic stoppers* are made of polyethylene plastic and vary in shapes. All have a dome-shaped head 31 to 33 mm in diameter and a hollow shank 18 to 18.5 mm in diameter and 30 to 35 mm long. On the shank are 4 to 6 raised rings 0.2 mm high. Plastic allows for slow passage of gases and the wine has a shorter shelf life than cork-sealed wine (2).
12. *Wire hoods* are used to secure the cork or plastic closure to the bottle. Hoods used for natural corks are 36 mm high with dome-shaped tinplate disk 29 mm in diameter. Wire hoods without disks are 32 mm high and are used for plastic stoppers (2).
13. *Carbon dioxide (CO_2) pressure testing apparatus* (optional)
14. *Freezer* (neck freezing)
15. *Dosage - syruping machine* (optional)
16. *Triple beam balance*
17. *Thermometer(s)*
18. *Refrigerator*
19. *Crown capper*
20. *Corker*
21. *Foils* (gold, red, pink) and foil crimper
22. *Aging cellar*
23. *Other*

Appendix

A. Approximate conversion to Metric Measures*

Symbol	When you know	Multiply by	To find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectars	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
		VOLUME		
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	centimeters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	degrees Farenheit	5/9 (after subtracting 32)	degrees Celsius	°C

*From "National Bureau of Standards, 1976, Special Publication 365, U.S. Department of Commerce, Washington, D.C. 20234."

B. Approximate conversion from Metric Measures*

Symbol	When you know	Multiply by	To find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectars (10,000m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1,000 kg)	1.1	short tons	
		VOLUME		
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic feet	yd^3
		TEMPERATURE (exact)		
°C	degrees Celsius	9/5 (then add 32)	degrees Farenheit	°F

---

*From "National Bureau of Standards, 1976, Special Publication 365, U.S. Department of commerce, Washington, D.C. 20234."

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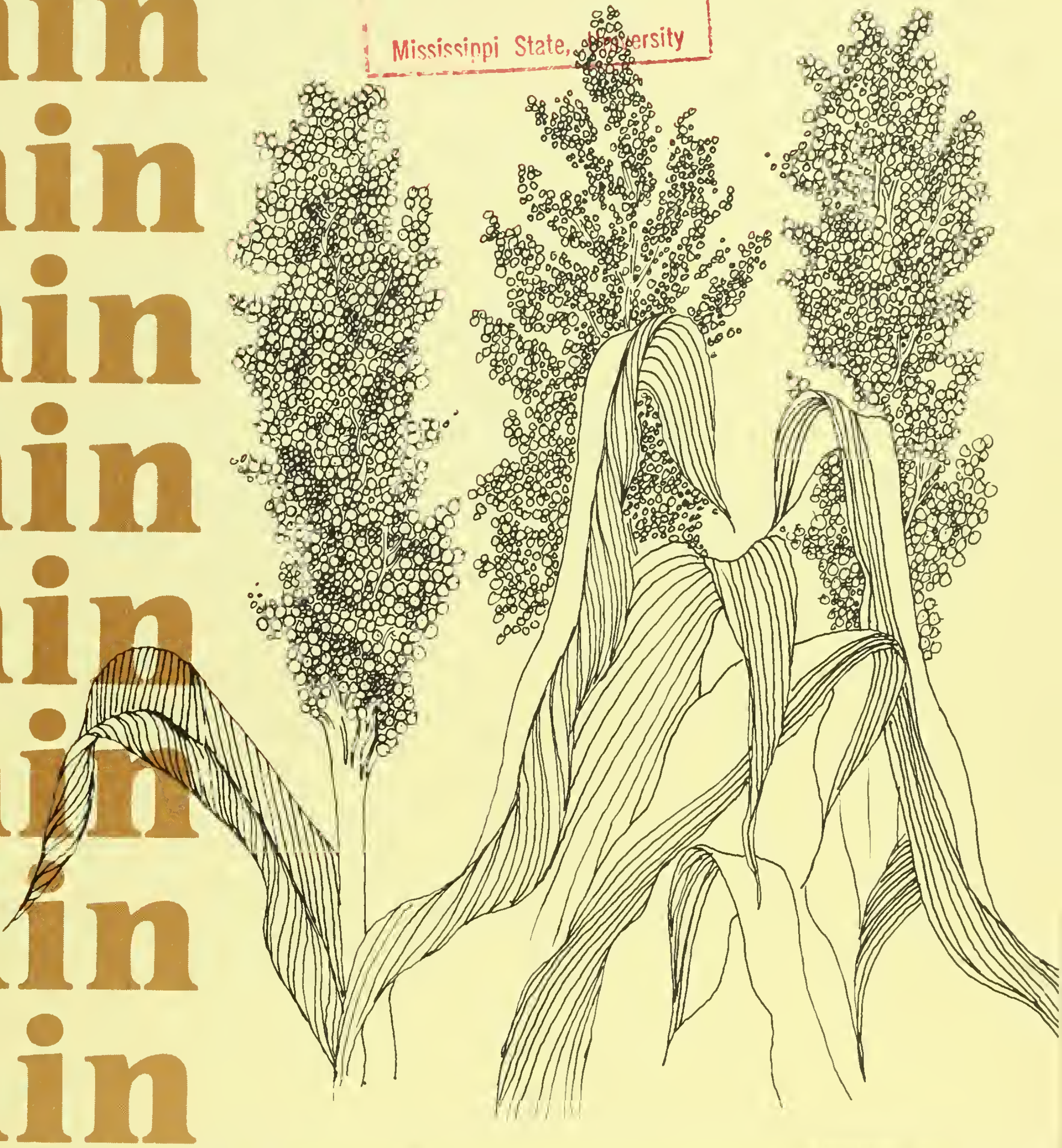

Mississippi Grain Sorghum Performance Trials 1981

MAFES MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION
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Mississippi Grain Sorghum Performance Trials 1981

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Hybrids designated for entry in the 1981 Mississippi Grain Sorghum Performance Trials by sponsors.

Hybrid	Brand	Company	Address
7623	Coker	Coker's Pedigreed Seed Co.	Lubbock, Texas
7638	Coker		
7675	Coker		
7737	Coker		
DK-42Y	DeKalb	DeKalb AgResearch, Inc.	Lubbock, Texas
DK-59	DeKalb		
DK-64	DeKalb		
1225 DR	Helena	Helena Chemical Co.	Memphis, Tennessee
1330 DR	Helena		
HT 126 DR	Hunt-Terra	Hunt-Terra Seed Co., Inc.	Lubbock, Texas
HT 128 GDR	Hunt-Terra		
656 BR	McNair		
550 G	McNair		
G-522 DR	Funk's	Louisiana Seed Co.	Plainview, Texas
G-611	Funk's		
G-522 A	Funk's		
G-1516	Funk's		
HW 5245	Funk's		
G-623 GBR	Funk's		
174	NC^+	NC^+ Hybrids	Hastings, Nebraska
Savanna 5	NK	Northrup King Co.	Columbus, Mississippi
2779	NK		
2670	NK		
2660	NK		
5550	PAG	PAG Seeds	Plainview, Texas
6658	PAG		
5514	PAG		
DR-1035	ACCO	Paymaster Seeds	Plainview, Texas
DR-1085	ACCO		
R 1090	ACCO		
B 815	Pioneer	Pioneer Hi-Bred Inter., Inc.	Tipton, Indiana
8308	Pioneer		
8311	Pioneer		
Dinero	T-E	Taylor-Evans Seed Co.	Tulia, Texas
Dinero-R	T-E		
W-839 DR	Warner	George Warner Seed Co.	Hereford, Texas
W-851 DR	Warner		
W-744 DR	Warner		

Mississippi Grain Sorghum Performance Trials 1981

Trials are conducted annually in Mississippi to provide farmers, seedsmen, extension personnel and other interested persons with information on performance of commercially available grain sorghum hybrids. Results are particularly helpful to grain sorghum producers in selecting hybrids suited to their area.

We tested 38 commercial and experimental hybrids at six locations in Mississippi in 1981 (Table 1). A good test of performance cannot be made if damaging populations of insects are present; therefore, insecticides were applied as needed. See MAFES Bulletins 817 and 836 for methods of control of insects on grain sorghum.

Table 1. Planting dates, fertilizer rates (lbs/A) and insecticides applied in Hybrid Grain Sorghum Performance Trials, by location of trials, Mississippi 1981.

Location	Planting date	Fertilizer rates[1]	Insecticides applied[2]
Mississippi State	May 17	25-25-85PP 100-0-0SD	2-diazinon
Holly Springs	June 10	78-78-78PP	3-sevin
Newton	May 6	52-52-52 34-0-0SD	None
Poplarville	May 18	68-0-0-SD	2-diazinon
Raymond	June 15	100-0-0SD	2-sevin
Verona	May 18	0-60-60PP 100-0-0SD	None

[1] SD = Sidedressed, PP = Preplant.
[2] Insecticides applied as labeled.

Resistance to diseases is important in selecting a hybrid for areas where diseases are a problem. Also, planting at the recommended time helps reduce damage caused by diseases and insects.

Testing Procedures

A randomized complete block design with three replications was used at all locations. Each plot consisted of two 20 ft-long rows 38 or 40 inches wide. All trials were planted at the rate of 7 lbs of seed per acre. Heads from 13 ft of each plot were hand-harvested, dried and threshed, and grain yield was adjusted to 14% moisture. Data reported have not been adjusted for bird damage, but trials severely damaged by birds were not harvested. Location of tests, planting dates, fertilizer rates and insecticides applied are presented in Table 1.

Results

Too few bird-resistant entries were received to permit a separate trial, and both bird-resistant and non-bird-resistant hybrids were tested in one trial at each location. Bird damage was recorded only at Mississippi State and Holly Springs, and damage averaged over the two locations ranged from 0 to 23% (Table 2). Bird damage at Mississippi State and Holly Springs, respectively, averaged 4% and 11% and ranged from 0 to 9% at Mississippi State and 0 to 40% at Holly Springs.

Lodging was negligible at all locations.

Grain yield of 38 hybrids in the 1981 trials ranged from 1140 lbs/acre for Funk's HW 5245 in the Verona trial to 6653 for N.K. Savanna 5 in the Mississippi State trial (Table 3). Yields averaged over all locations ranged from 2808 lbs/acre for Pioneer Brand 8311 to 3669 lbs for N.K. Savanna 5.

Quantity of harvested good-quality grain (or silage) is the best guide to the desirability of sorghum hybrids; however, performance data for any one year may be misleading. Therefore, the two- and three-year average yields of hybrids that have been evaluated for these periods of time also are presented (Tables 4 and 5).

Table 2. Performance of 38 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location, 1981.

Hybrid	Brand	50%[1] Bloom	Plant[2] height	Yellow Sorghum Stunt[3] Plants affected	Yellow Sorghum Stunt[3] Effect on growth	Disease[4] rough spot	Seed[5] mold	Bird[6] damage	Test[7] weight
		(days)	(in.)	(%)	(rating)	(rating)	(rating)	(%)	(#/bu)
Savanna 5	N.K.	59	58	5	0	1	1	1	60.5
B 815	Pioneer	59	54	0	0	1	1	1	56.3
2660	N.K.	58	46	80	2	2	2	10	56.5
174	NC+	60	50	40	0	1	2	10	59.0
G-1516	Funk's	61	48	0	0	1	2	0	56.5
G-522 DR	Funk's	59	46	0	0	1	4	10	56.0
1225 DR	Helena	59	48	60	1	2	3	7	58.0
W-839	Warner	58	46	60	1	2	2	5	57.0
8303	Pioneer	59	47	30	2	1	3	10	57.6
7675	Coker	58	47	40	1	1	3	9	55.8
W 851 DR	Warner	59	47	70	1	2	2	5	57.3
2670	N.K.	58	51	20	2	1	3	10	57.0
R 1090	Acco	59	49	20	1	2	3	9	58.0
6658	P-A-G	58	51	80	1	2	1	8	57.4
7638	Coker	57	44	10	2	1	2	11	57.7
Dinero	T-E	59	46	50	2	1	3	9	56.3
G-522 A	Funk's	58	44	40	2	1	3	10	54.8
DK-59	DeKalb	62	45	10	0	1	3	6	56.4
HT 128 GDR	Hunt	59	50	10	2	1	1	9	60.7
7623	Coker	59	52	70	2	2	2	23	57.5
Dinero R	T-E	58	46	50	2	1	3	11	53.4
1330 DR	Helena	60	53	20	0	1	2	19	58.0
DR 1035	Acco	60	46	60	1	1	3	10	58.0
656 BR	McNair	60	50	0	0	1	1	0	55.4
W-744 DR	Warner	59	49	40	1	1	1	0	59.6
HW 5245	Funk's	64	46	20	1	1	2	4	58.5
DR 1085	Acco	59	47	40	1	1	3	11	57.7
DK-64	DeKalb	59	53	0	0	1	2	11	61.3
HT 126 DR	Hunt	58	48	20	0	1	1	10	58.5
G-611	Funk's	59	50	40	2	1	4	7	56.3
7737	Coker	61	49	30	1	1	3	7	56.6
550 G	McNair	60	47	0	0	1	2	4	55.2
5514	P-A-G	57	45	20	1	2	2	7	58.5
DK-42Y	DeKalb	60	46	20	0	2	2	7	59.8
2779	N.K.	58	44	20	1	2	3	8	54.9
G-623 GBR	Funk's	59	45	10	1	2	2	3	53.5
5550	P-A-G	59	46	70	0	2	2	5	53.6
8311	Pioneer	58	45	20	0	2	2	8	53.1
	Mean	59	48	31	0.9	1.3	2.2	7.8	57.1

[1,2] Average of Holly Springs, Newton and Mississippi State

[3,4,5] Rated at Meridian, Miss. by Dr. Natale Zummo. Yellow Sorghum Stunt - Plants affected is the percentage of the plants with symptoms. Effect on growth - rating of 0 = No effect, 4 = severe stunting. Rough Spot - rating of 0 = No disease symptoms, 4 = disease killed plants. Seed mold - 0 = No molded seeds, 4 = severe seed mold and weathering.

[6] Average of Holly Springs and Mississippi State

[7] Mississippi State only.

Table 3. Yield of 38 grain sorghum hybrids in Mississippi Grain sorghum Performance Trials, by hybrid and location, 1981.

		Yield						
Hybrid	Brand	Miss. State	Holly Springs	Newton	Poplarville	Raymond	Verona	Mean
		lbs/acre						
Savanna 5	N.K.	6653	1804	2195	3537	4064	3761	3669
B 815	Pioneer	5168	2699	2187	3463	4213	3522	3542
2660	N.K.	5372	2299	1591	3667	4228	3729	3481
174	NC+	5389	2253	1852	3953	4356	2889	3449
G-1516	Funk's	5647	2284	1599	3193	4607	2800	3355
G-522 DR	Funk's	5946	2464	2220	2932	3845	2562	3330
1225 DR	Helena	5507	2334	1942	2842	4271	2795	3282
W-839	Warner	5505	2365	1412	2965	4254	3167	3278
8303	Pioneer	5685	2491	1493	3373	3356	3092	3248
7675	Coker	5482	2402	1599	2867	3948	2976	3212
W 851 DR	Warner	5147	1479	2464	3390	4542	2238	3210
2670	N.K.	5194	2122	1501	3063	3867	3305	3175
R 1090	Acco	5350	2493	1493	2581	3923	3108	3158
6658	P-A-G	5482	2373	2024	2338	3489	3171	3145
7638	Coker	4898	1688	2432	2997	3583	3241	3240
Dinero	T-E	4910	2379	1901	3324	3723	2562	3133
G-522 A	Funk's	5321	2146	1967	2891	3972	2429	3121
DK-59	DeKalb	5592	1893	1370	3242	3626	2960	3114
HT 128 GDR	Hunt	5205	1585	1958	2818	3719	3267	3092
7623	Coker	5139	1705	1681	3398	3826	2742	3082
Dinero R	T-E	4673	2251	2358	3030	3948	2260	3087
1330 DR	Helena	5330	2455	1485	3104	3687	2285	3058
DR 1035	Acco	4895	2043	1738	2434	3768	3469	3058
656 BR	McNair	4593	1778	1338	3880	3960	2785	3056
W-744 DR	Warner	5238	1837	1893	3439	3307	2557	3045
HW 5245	Funk's	5530	2015	2285	3226	4045	1140	3040
DR 1085	Acco	4931	2328	1640	2695	3441	3143	3030
DK-64	DeKalb	5558	2045	1657	3071	4140	1565	3006
HT 126 DR	Hunt	4777	2042	2097	3537	3049	2451	2992
G-611	Funk's	5456	2063	1314	2573	3687	2800	2982
7737	Coker	5321	1790	1510	2818	4556	1712	2951
550 G	McNair	4960	1913	1363	3030	3430	3008	2947
5514	P-A-G	4361	1816	1999	2769	3601	3066	2935
DK-42Y	DeKalb	5143	1831	2040	2883	3390	2313	2933
2779	N.K.	4687	2455	1248	2156	3527	3432	2918
G-623 GBR	Funk's	5071	2048	1893	3357	3062	1846	2880
5550	P-A-G	4644	2334	1991	3234	3577	1437	2870
8311	Pioneer	4572	1763	1591	3087	3233	2599	2808
	Mean	5220	2107	1798	3083	3822	2750	3130
	LSD (.05)	718	443	819	1156	846	1147	--
	CV	8.5%	12.9%	28.0%	23.1%	13.6%	25.7%	--

Table 4. Two-year average (1980-81) yield of 13 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location of trials.

		Yield				
Hybrid	Brand	Mississippi State	Newton	Raymond	Verona	Mean
		lbs/acre				
Savanna 5*	N.K.	5549	2362	5475	3981	4342
G-522 A	Funk's	5094	2021	5827	----	4314
Dinero	T-E	4612	2286	5884	----	4261
DK-64	DeKalb	4385	2620	5726	----	4244
B 815*	Pioneer	5111	2220	5537	3749	4154
7675	Coker	5008	1485	5442	----	3978
G-611	Funk's	4724	1717	5464	----	3968
2670	N.K.	4212	2108	5474	----	3931
7638	Coker	4040	2431	5266	----	3912
G-522 DR	Funk's	5286	1850	5769	2625	3883
7737	Coker	4837	2009	6243	2396	3871
2779	N.K.	3923	1662	5227	----	3604
8311	Pioneer	4010	1791	4900	2868	3392
Mean		4676	2043	5556	3124	3989

*Bird-resistant hybrid

Table 5. Three-year average (1979-81) yield of 10 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location of trials.

		Yield				
Hybrid	Brand	Mississippi State	Newton	Raymond	Verona	Mean
		lbs/acre				
Savanna 5*	N.K.	5084	4199	4659	4647	
G-522 DR	Funk's	5030	3785	----	4408	
7737	Coker	4979	3791	----	4385	
B 815*	Pioneer	4686	3634	4764	4361	
7675	Coker	5084	3033	----	4059	
Dinero	T-E	4730	3319	----	4025	
DK-64	DeKalb	4523	3514	----	4019	
7638	Coker	3941	3676	----	3809	
8311	Pioneer	3927	3128	----	3528	
2779	N.K.	3843	2769	----	3306	
Mean		4583	3485	4712	4055	

*Bird-resistant hybrid

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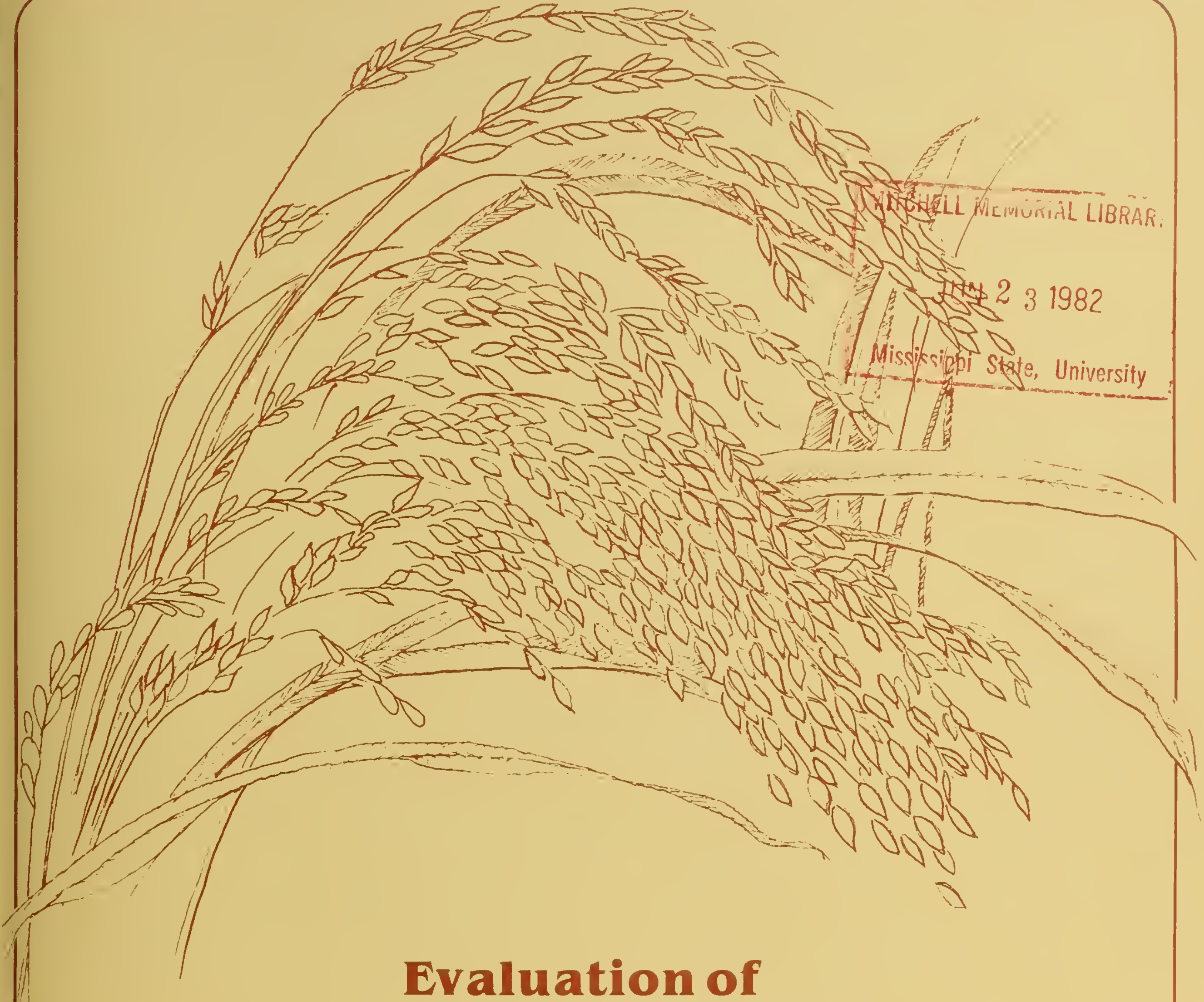

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Evaluation of Fungicides for Treatment of Rice Planting Seed, 1976-81

R. G. Davis

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Evaluation of Fungicides for Treatment of Rice Planting Seed, 1976-81

Treatment of planting seed with fungicides is an accepted practice for control of seed- and soilborne-diseases that affect seedling stands and development of crops. Seed and seedling diseases of rice are common in Mississippi and may be related to the stresses caused by early or late plantings and conditions that impede germination and growth of rice seed. Effectiveness of seed treatment with fungicides in tests has been reported in Louisiana (1). This report summarizes the results of six years of fungicide trials with rice in Mississippi.

Procedure

The test materials (Tables 1-8) and seed were stirred or tumbled in a jar or a plastic bag. The treated seed were sown with a one-row, push-type plot planter at a rate of 20/ft in 10-ft long rows. The design was a randomized block with five replications. Tests were planted on a Sharkey clay in 1976-80 and on a Bosket fine sandy loam in 1979-81. Stand counts usually were made during the early seedling stage.

Results and Discussion

Fungicidal treatments generally increased stand (Tables 1-8), but the 1977 test showed that seed dressings are not always associated with improved stand. The 1977 test was planted on a rough, poorly pulverized seedbed, and plant stands for all treatments were low, indicating that seedbed condition rather than seed dressings limited stand. Seed and seedling disease pressure were low in the 1980 test on Sharkey clay and in the 1981 test, and this prevented identification of effective treatments. Such uncontrollable factors make the selection of effective treatments more difficult.

Fungicides suggested for use on rice planting seed in Mississippi (Arasan 42-S®, Arasan 70-S®, Busan 30A®, Captan®, Difolatan 4F®, Dithane M-45®, Terracoat L-205® and Vitavax R®[1]) were included in most tests. Effectiveness of the suggested materials generally was satisfactory. There was variability among years. Higher seedling stands than those of the control usually were associated with one or more of the suggested materials in years when conditions were such that differences between treatments were evident.

Several experimental fungicides were evaluated each year. Some of these materials resulted in better stands, but their status as possible new fungicides for rice seed is uncertain.

Acknowledgment

Seed used in the regional rice seed treatment tests have been treated and distributed by either F. N. Lee, Arkansas Agricultural Experiment Station, Stuttgart; or M. C. Rush, Louisiana Agricultural Experiment Station, Baton Rouge. D. H. Bowman, T. C. Miller and J. E. Street, MAFES Delta Branch, are thanked for their assistance.

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[1] *Mississippi Cooperative Extension Service. Rice Seed Treatment, Plant Disease Dispatch, October 1978.*

Table 1. Rice seedling survival in the 1976 regional rice seed treatment test, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Difolatan-Vitavax (2-2) Fl SP	4	60.2**
DPX 14	4	56.2**
H 719 Fl (17%) + Difolatan 4 Fl 50% + 50% Tank Mix	2	55.8**
Terracoat L-205 + OAC 5-1563	4 + 2	55.0**
Captan 4 Fl	3.4	53.0*
H 719 Fl (17%) + Difolatan 4 Fl 50% + 50% Tank Mix	4	52.7*
Demosan T	6	51.5*
Dithane M-45	4	49.1
Difolatan 4 Fl+ Kocide SD 50% + 50% Tank Mix	8	49.0
RE 19656 50 W	6	48.8
Difolatan 4 Fl + Vitavax-R 50% + 50% Tank Mix	4	48.7
Orthocide-Vitavax (37.5 - 37.5) WP	2	48.5
Kocide SD	8	47.9
Chapman C-22	4	47.7
Arasan 70-S	2.35	47.4
Vitavax-R	4	47.1
Terracoat SD-205 + OAC 5-1563	4 + 2	46.3
Difolatan 4 Fl SP	4	46.2
Difolatan 4 Fl + Vitavax-R (2:1)	4	45.8
Guardsan 389 40 WP	6	44.9
Kocide SD	4	44.8
Terracoat L-205	8	44.7
Vitavax-17	4	44.2
Chapman C-44	4	43.7
Guardsan 389 40 WP	8	43.4
Terracoat ZN 20-5-5	5	43.2
Terracoat L-205 + OAC 5-1484	4 + 2	42.6
Difolatan 4 Fl + Vitavax-R (1:2)	4	42.6
Vitavax-17	8	41.9
Orthocide-Methoxychlor 75-5 WP	2.25	41.3
Busan 30 EC	1.65	41.2
Vitavax-17	2	41.1
Untreated seed	-	39.6
Terracoat L-205	4	38.7
Bay Meb 6447	2	37.6

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[1] Rice cultivar - Starbonnet
Soil type - Sharkey clay
Planting date - 4-23-76
Date stand counted - 6-10-76

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level. LSD 0.01 = 14.1. LSD 0.05 = 10.7.

Table 2. Rice seedling survival in the 1977 regional rice seed treatment test, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Untreated check	---	30.8
Orthocide-Vitavax (37.5 - 37.5) SP	6.00	27.6
Arasan 70S Red	2.35	27.4
DPX-14	6.00	26.5
Kocide SP	4.00	26.3
Difolatan 4F + Vitavax R (50%-50% tank mix)	8.00	26.0
MRC 156C	6.00	26.0
Dithane M-45	4.00	25.2
Terracoat ZN 2055	5.00	25.2
Terracoat ZN 2055	3.00	24.6
Arasan 70S Red + Zinc Oxide	2.35 + 4.00	24.6
Terracoat L-205	8.00	24.4
Orthocide-Methoxychlor	2.25	24.2
Vitavax-R	4.00	24.1
Difolatan-Vitavax (2-2) fl.	4.00	22.8
Terracoat L-205 + OAC 5-1563	4.00 + 2.00	22.6
DPX-14	4.00	22.2
OAC 5-1563	2.00	21.5
Orthocide-Vitavax (37.5 - 37.5) SP	4.00	20.1
UBI P-368	4.00	20.0
RH-2161	1.00 ai	19.9
Chapman 22	4.00	19.2
UBI 1196	4.00	18.7
RH-2161	2.00 ai	18.6
Difolatan 4F	4.00	18.2
OAC 5-1563	4.00	18.2
Terracoat L-205	4.00	16.4
UBI 1196	12.00	15.2
UBI 1196	8.00	15.3
Guardsan 389 WP	4.00	14.8
Guardsan 388 WS	4.00	11.3
EL 228 WP	6.00	9.2

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[1] Rice cultivar - Labelle
Soil type - Sharkey clay
Planting date - 5-9-77
Date stand counted - 6-13-77

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level. LSD 0.01 = 13.4. LSD 0.05 = 10.2.

Table 3. Rice seedling survival in the 1978 regional seed treatment test, by treatment, MAFES Delta Branch.[1]

Treatment		Rate (oz/cwt)	Stand[2] (%)
DPX 14		4.00	24.2**
Difolatan 4F		6.00	22.6**
CGA-48988 + Vitavax 17F		1.0 + 8.0	22.0**
CGA-48988 2EC + Vitavax 17F		2.0 + 8.0	20.0**
UBI P-368		6.00	18.8**
CGA-48988 2EC		2.00	18.4**
RH 2161		4.00	18.2**
Captan 80WP		2.25	17.8**
ABG-2000 + Difolatan 4F		2.0 + 4.0	17.4**
Terracoat L-205		8.00	17.0*
UBI P-368		4.00	16.6*
Difolatan 4F		4.00	16.0
CGA 48988 + Terracoat LT-2		1.0 + 4.0	15.8
Terracoat ZN 2055		5.00	15.6
Benlate-T		4.00	14.4
UBI P-368 + Vitavax 75	(tank mix)	3.0 + 3.0	14.2
Chapman-22		4.00	14.2
Kocide SD		4.00	13.4
Terracoat ZN 4-1-1-F		4.00	13.4
ABG-2000 + Kocide SD		2.0 + 4.0	13.2
ABG-2000		4.00	13.0
Untreated		---	12.8
Vitavax-R		4.00	12.6
Kocide SD		8.00	11.8
CGA-49899 2EC + Terracoat LT-2		2.0 + 4.0	11.8
CGA-48988 2EC		1.00	11.6
Orthocide - Methoxychlor 75-5		2.25	11.4
Dithane M-45		4.00	11.0
Arasan 705 Red		2.35	8.8
MRC 156C		6.00	7.2

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[1] Rice cultivar - Labelle
Soil type - Sharkey clay
Planting date - 4-21-78
Stand counting date - 5-25-78

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level. LSD 0.01 = 4.6. LSD 0.05 = 3.5

Table 4. Rice seedling survival in the 1979 regional seed treatment test, Location 1, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Difolatan 4 Fl	6.0	33.0**
Dithane Fl-45	4.0	32.9**
UBI - P368	4.0	32.8**
DPX 770-2	4.0	31.0**
Terracoat Zn 20-5-5WP	5.0	28.7**
Chapman PQ-572	8.00	28.2**
DPX 115 B	4.0	27.9**
Captan 80 WP	2.25	27.6**
Orthocide 4 Fl	3.40	27.5**
DPX 770	4.0	27.4**
CZ 57	6.0	26.6*
CGA-48988 (Ridomil)	2.0	25.2*
Gustafson Captan 30 DD + Gustafson 42 S	2.70 + 3.15	25.1*
Busan 30A	1.5	25.0*
Gustafson Captan 30 DD	2.70	24.4
Gustafson Captan 30 DD + Vitavax 30 C	2.70	24.2
Kocide SD	4.0	23.9
Gustafson 42 S	3.15	23.6
Chapman PQ-56	8.0	23.5
Terracoat Zn 20-5-5 WP	5.0	23.0
Vitavax-R	4.0	21.8
Kocide Zn SD	4.0	21.3
Terracoat 20-5 Fl	5.0	20.6
CGA-48988 + Vitavax-17 Fl	1.0 + 8.0	20.6
CGA-48988 + Terracoat LT-2	1.0 + 4.0	20.3
DAC 3289 + PCNB (17%-17%) Fl	4.0	18.9
Vitavax 34 Fl	2.00	17.7
Untreated	---	16.6
Terracoat L-205	8.00	16.6
CGA-48988 + CGA-64250	1.0 + 2.0	14.8

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[1] Rice cultivar - Labelle
Soil type - Sharkey clay
Planting date - 6-13-79
Stand counting date - 7-3-79

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level. LSD 0.01 = 10.8. LSD 0.05 = 8.2.

Table 5. Rice seedling survival in the 1979 regional seed treatment test, Location 2, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Gustafson Captan 30 DD + Gustafson 42 S	2.70 + 3.15	59.2**
DPX 770-2	4.0	58.2*
Terracoat Zn 20-5-5 WP	5.0	56.8*
Captan 80 WP	2.25	55.5
Dithane F1-45	4.0	54.3
UBI - P 368	4.0	53.5
Difolatan 4 F1	6.0	53.5
Gustafson Captan 30 DD	2.70	53.5
Orthocide 4 F1	3.40	53.4
Gustafson Captan 30 DD + Vitavax 30 C	2.70	52.4
Kocide SD	4.0	52.1
DPX 770	4.0	52.0
Gustafson CZ 57	6.0	52.0
CGA-48988 Vitavax 17 F1	1.0 + 8.0	50.9
DPX 115 B	4.0	50.8
Vitavax-R	4.0	48.9
Terracoat ZN 20-5-5 WP	5.0	48.1
Chapman PQ-56	8.0	47.7
Vitavax 34-F1	2.00	47.2
Kocide Zn SD	4.0	46.9
Gustafson 42 S	3.15	46.6
Terracoat 20-5 F1	5.0	45.8
CGA-48988 (Ridomil)	2.0	45.8
Untreated	---	44.9
Busan 30A	1.5	44.6
CGA-48988 + Terracoat LT-2	1.0 + 4.0	44.0
Chapman PQ-572	8.00	41.0
Terracoat L-5=205	8.00	40.1
DAC 3289 + PCNB (17%-17%) F1	4.0	38.1
CGA-48988 + CGA-64250	1.0 + 2.0	29.5

[1] Rice cultivar - Labelle
Soil type - Bosket fine sandy loam
Planting date - 5-1-79
Stand counting date - 5-13-79

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level. LSD 0.01 = 14.1. LSD 0.05 - 10.7.

Table 6. Rice seedling survival in the 1980 regional seed treatment test, Location 1, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Busan 30A	1.5	49
CGA-48988 + Vitavax-34	1.0 + 3.0	48
Vitavax-34	3.0	48
Captan 80 WP	2.25	47
Dithane M-45 F	4.0	47
Orthocide 4 F	3.4	47
Terracoat L-205	8.0	47
Untreated control	---	46
Difolatan 4 F	4.0	46
CGA-48988 (Ridomil)	1.0	45
CGA-48988 + Vitavax R	1.0 + 3.0	44
Dithane M-45 WP	4.0	44
Difolatan 4 F	6.0	43
Kocide SD	4.0	43
Terracoat Zn 20-5-5 WP	5.0	43
Gustafson 42 S	3.3	43
Vitavax-R	4.0	42
Vitavax-R + Gustafson 42 S + Protoective binder	3.0 + 5.3 + 2.0	42
Terracoat Zn 20-5-5 FL	5.0	40
Gustafson-Captan 30 DD	2.7	38

[1] Rice cultivar - Labelle
Soil type - Sharkey clay
Planting date - 5-8-80
Stand counting date - 5-26-80

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level.
LSD 0.01 = 10.8. LSD 0.05 = 8.2.

Table 7. Rice seedling survival in the 1980 regional seed treatment test, Location 2, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Vitavax 34	3.0	49**
CGA-48988 + Vitavax R	1.0 + 4.0	44**
Difolatan 4 F	6.0	43**
Difolatan 4 F	4.0	43**
Vitavax-R	4.0	42**
Dithane M-45 F	4.0	42**
Terracoat L-205	8.0	41*
Captan 80 WP	3.25	40*
Dithane M-45 WP	4.0	38*
Terracoat Zn 20-5-5 FL	5.0	36
Gustafson-Captan 30 DD	2.7	36
Gustafson 42 S	3.3	33
Busan 30A	1.5	33
Terracoat Zn 20-5-5 WP	5.0	32
CGA-48988 + Vitavax 34	1.0 + 3.0	32
Vitavax-R + Gustafson 42 + protective binder	3.0 + 5.3 + 2.0	32
Kocide SD	4.0	29
Orthocide 4 F	3.4	28
CGA-48988 (Ridomil)	1.0	27
Untreated control	---	23

[1] Rice cultivar - Labelle
Soil type - Bosket fine sandy loam
Planting date - 4-23-80
Stand counting date - 5-8-80

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level.
LSD 0.01 = 18.5. LSD 0.05 = 14.0.

Table 8. Rice seedling survival in the 1981 regional seed treatment test, by treatment, MAFES Delta Branch.[1]

Treatment	Rate (oz/cwt)	Stand[2] (%)
Apron + Vitavax-R + Durakoat	2.00 + 4.00 + 6.00	65*
Zinc Omadine 40% WP	1.00	64*
Apron + Vitavax-R	2.00 + 4.00	64*
Orthocide 4 Fl	3.25	62*
Vitavax R	4.00	62*
Dithane M-45 Fl	4.00	60
Zinc Omadine 40% WP + Olin 4001	0.50 + 12.5	58
Difolatan 4 Fl	6.00	58
Difolatan 4 Fl	4.00	57
Captan 30 DD	2.70	57
Apron	2.00	57
Apron + Durakoat	2.00 + 6.00	56
Imazalil 5% SD + TCMB 10% SD	0.1 g/kg	55
SC-0785	3.00	55
Thiram 30 F	3.30	54
Imazalil 5% SD	0.1 g/kg	52
Imazalil 5% SD	0.1 g/kg	51
SC-0785	1.50	51
Untreated	---	49
Imazalil 5% SD + TCMB + 10% SD	0.1 g/kg	48
Olin 3900	5.60	40
Olin 3900 + Olin 4001	2.80 + 2.5	29

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[1] Rice cultivar - Labelle
Soil type - Bosket fine sandy loam
Planting date - 5-11-81
Stand counting date - 5-25-81

[2] Expressed as percent of seed planted, mean of five replications. Means followed by asterisks are significantly higher than the mean stand from untreated seeds at the 1% (**) or 5% (*) level.
LSD 0.01 = 16.3. LSD 0.05 = 12.4.

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Bulletin 905

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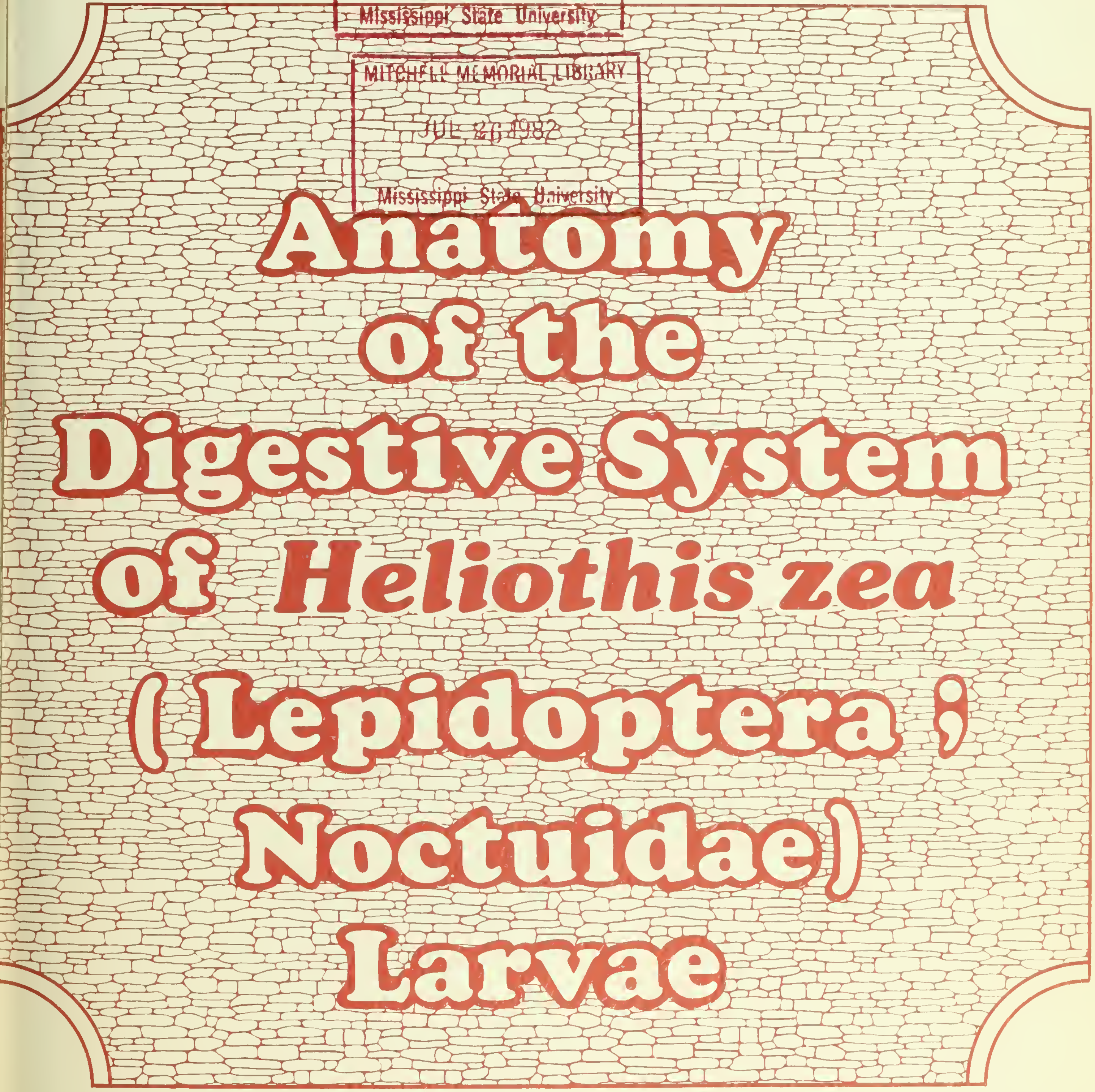

Anatomy of the Digestive System of *Heliothis zea* (Lepidoptera; Noctuidae) Larvae

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P. P. Sikorowski, Professor and Entomologist
MAFES/MSU, Department of Entomology

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Anatomy of the Digestive System of *Heliothis zea* Larvae

Heliothis zea (Boddie) is a major pest of agricultural crops and is ubject to extensive research. Several papers discuss the anatomy of this or related species, but a horough anatomical treatment of he digestive system is lacking. Therefore, the anatomy of this species must be inferred from more nclusive studies.

Chauthani and Callahan (1967) first described the gross morphology, with corrections made ater by Standlea and Yonke (1968). Chi et al. (1975) discussed the comparative morphology and histology of *Heliothis virescens* (F.), *H. zea* (Boddie) and *Spodoptera ornithogalli* (Guenee) and *S. frugiperda* (Smith) on the basis of gross dissection and light microscopy. Studies of *Hyalophora cecropia* by Judy and Gilbert (1969, 1970), traced the changes that occur during metamorphosis. Reinecke, Cook and Adams (1973), provide an excellent account of the hindgut musculature of *Manduca sexta;* Byers and Bond (1971), provide a topographic study of the hindgut of several species of Lepidoptera, including the Noctuidae, and Saini (1964) gave a concise anaysis of the cryptonephridial system of several superfamilies of beetles and of Lepidoptera.

Our study provides a comprehensive histological and topographical treatment of the digestive system, by means of light microscopy and SEM, of mature laboratory reared larvae of *H. zea* taken before the prepupal stage after feeding on artificial diet. This should lead ideally to developmental studies of each instar because a great many changes occur between and during molts, especially as the insect enters the prepupal stage.

Methods and Materials

Last instar larvae of *H. zea* were taken before the prepupal stage from cultures in our laboratory and were processed for histological observations or for scanning electron microscopy. A reasonable degree of uniformity was assured by dividing ten larvae from each rearing lot into two groups of five, for light microscopy and SEM. The procedures were repeated several times over a one-year period. Specimens used for light microscopy were killed and fixed by injection before storage in Bakers' formalin (Humason 1967) or Perfix® (Fisher Sci. Co.). Those fixed in Bakers' formalin (24 hr at room temperature) were processed (1) through 30-50-70-95% ethanol to absolute EtOH-Xylene and Xylene/paraplast 1:1, (2) to melted paraplast at 57°C and, infiltrated 2 hr under 30 cm vacuum and (3) were embedded. Dehydration fluids were changed three times each at 15 minute intervals.

Specimens fixed in Perfix were carried directly to 95% EtOH, and processed as those fixed in Bakers' formalin. The larvae were cut into sections of 1-3 segments long before dehydration to aid in rapid processing. Sections were cut at 2-10 μm on a rotary microtome, rehydrated, stained in Gill hemotoxylin No. 2 (Anon. 1976), dehydrated, counterstained in eosinated absolute ethanol, cleared and covered for observation. Most sections required destaining of the hematoxylin by 0.5% HCl. Extrusion vesicles of the midgut epithelium were subjected to the Feulgen reaction by following precisely the methods of Gurr (1962), using an eight minute hydrolysis period.

Specimens for SEM were killed and fixed by injection with either of the above agents. The larvae either were cut into three segments or the entire digestive systems were removed. These tissues were postfixed in OsO_4 for four-to-seven hr, and were dehydrated through graded alcohols and immersed in three-to-five min changes of freshly opened absolute EtOH just before critical point drying with CO_2. The digestive systems were dissected on SEM stubs, were coated with gold on a Hummer II® sputtering device and were examined on a Hitachi HHS-2R® scanning electron microscope at an accelerating voltage of 20kV.

Photomicrographs were made on a Leitz Ortholux® microscope with Kodak Panatomic-X® film (ASA 32), a Nikon® camera back provided with automatic metering and shutter controls and with Tri-X-pan® 4x5 film in a Leitz Aristophot® bellows camera. Scanning electron micrographs were made on Polaroid® 55 film.

Descriptive Anatomy

Foregut (Figs 1-4)

Foregut consists of the buccal cavity, anterior and posterior pharynx, esophagus and crop, and terminates inside the anterior interstitial ring (AIR) of the midgut (Figs. 1-4). Epithelium of the buccal cavity is covered by a relatively thick intima. Various authors have cited specific dimensions for the thickness of the intima; but, in our experience, the thickness of both fore and hindgut intima is extremely variable. However, topographic features remain constant.

The intima of the buccal cavity is thoroughly covered with very fine, sharply pointed spicules as far back as the anterior pharynx. The anterior pharynx is a swollen area of the foregut that is convoluted in cross section and found anterior to the subesophageal ganglion. The food tube narrows above the subesophageal ganglion, with another dilation at the caudal end of the posterior pharynx. The entire pharynx bears small caudally directed spicules that are stouter than those of the buccal cavity, but they are not easily visualized in light microscopy because of the irregularities of the intima.

The esophagus originates at the end of the last internal lobe of the posterior pharynx and extends back to the crop. It consists of a very flat epithelium with widely spaced nuclei closely flattened against the intima. The esophagus widens at the crop, and there is no clear distinction between the two.

The epithelium of the crop remains flattened against the intima, and cell borders of both crop and esophagus are obscure (Fig. 4). The crop extends, apparently unmodified, into the anterior opening of the midgut and terminates inside the first plica of the midgut.

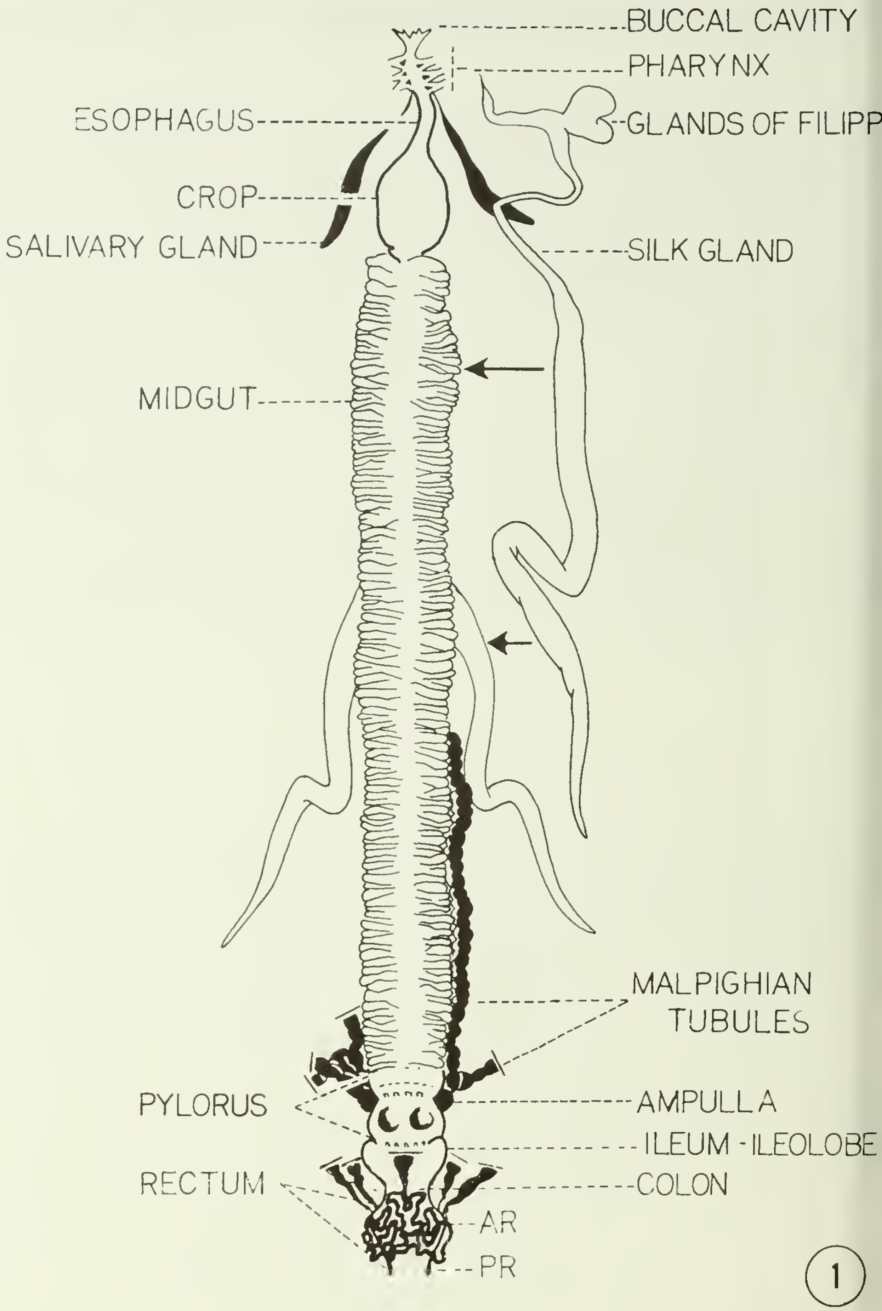
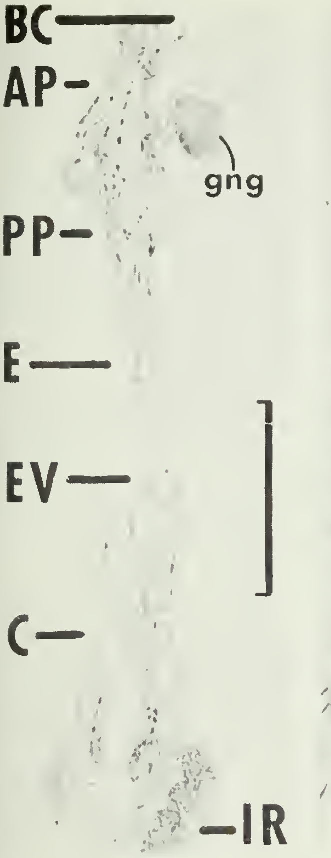


Figure 1. Generalized diagram of *Heliothis zea* larval digestive system, drawn and reduced from a large composite scanning electron micrograph. AR, anterior rectum, PR, posterior rectum.

The transition from foregut to midgut is marked clearly by the narrow band of cells of the AIR, composed of cuboidal epithelium with large nuclei closely packed against the cell membranes. A similar series of cells occurs at the posterior end of the midgut. The musculature of the anterior and posterior pharynx is well veloped, consisting of stout circu and longitudinal muscles and t dorsal and ventral dilators of t pharynx.



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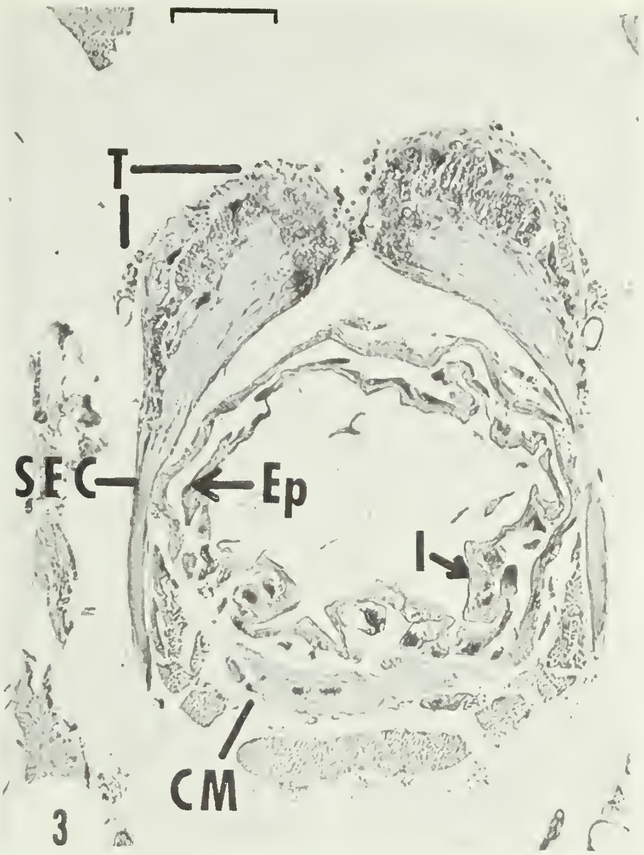

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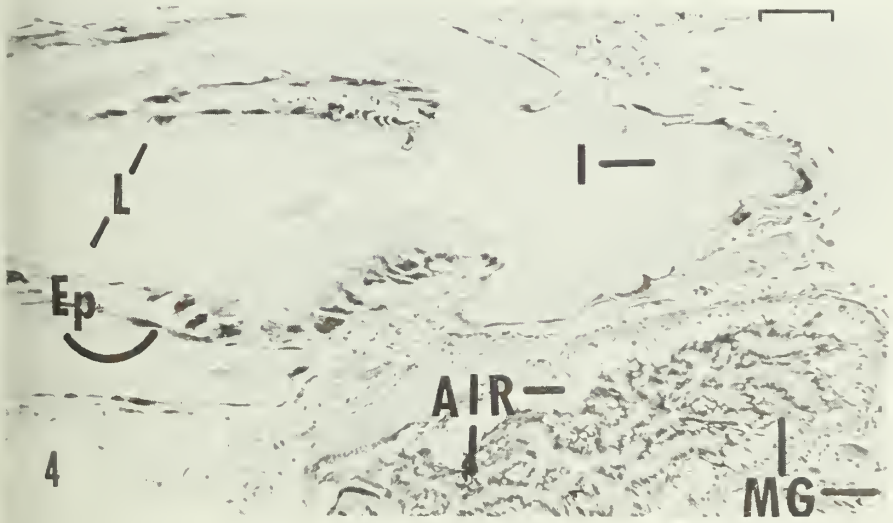

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Figure 2. Overview of foregut in sagittal section. AP, anterior pharynx; BC, buccal cavity; C, crop; E, esophagus; EV, esophageal valve; IR, interstitial ring of anterior midgut; gng, ganglion. Bar = 500 μm. Figure 3. Transection of pharynx at tritocerebrum. CM, circular muscle; Ep, epithelium; I, intima; SEC, subesophageal connective; T, tritocerebrum. Bar = 100 μm. Figure 4. Sagittal section through crop. AIR, anterior interstitial ring; Ep, epithelium (extremely flattened); I, intima; L, lumen; MG, midgut. Bar = 100 μm.

Midgut (Figs. 5-14, 24)

The midgut consists of a long tube of epithelial cells bound by a basement membrane and circular and longitudinal muscles and originates at the anterior interstitial ring. The midgut is incised transversely by constrictions that throw the epithelium into regular folds (Figs. 5, 24), each consisting of a number of goblet cells with large interior cavities and adjacent columnar cells (Figs. 12-14). The columnar cells are very narrow and are compressed between the goblet cells so that they appear to be a majority of the latter; however, this is misleading and there are at least four columnar cells per goblet cell; and the columnar cells account for the striated border of the epithelium.

Goblet cell cavities appear mainly in the upper 1/2 of the cell, the nuclei below (Fig. 24). The cavities vary from about 18-35 μm long and 7-10 μm across and contain microvilli about 2 μm long and 0.25 μm broad (Figs. 13, 14).

The post-digestive processes are marked by extrusion of vesicles from the cells into the lumen (Figs. 6-11, 24). The vesicles give a negative Feulgen reaction but retain Gill hematoxylin in regressive staining. The literature appears vague as to the identity of these extrusion bodies; i.e., whether they are packets of cellular breakdown products, contain enzymatic substances that digest the food or are extruded nuclei from degenerating epithelial cells. Regressive staining by hematoxylin suggests nuclei because the vesicles retain the stain well. However, the Feulgen-schiff reaction is negative, hence the absence of DNA is demonstrated.

Specific enzymatic tests were not performed, but the great increase in extrusion vesicles after digestion, especially before and entering the prepupal stage, suggests that the vesicles are probably cellular breakdown products released into the gut lumen and that the enzymatic release probably occurred as secretion from the epithelium much before the development of the vesicles. This seems much more plausible, especially since there is no way that the vesicles could penetrate the peritrophic membrane. Thus, in this view, what appears to be merocrine secretion is suggested to be the release of cell breakdown products after digestion (in the form of the extrusion vesicles).

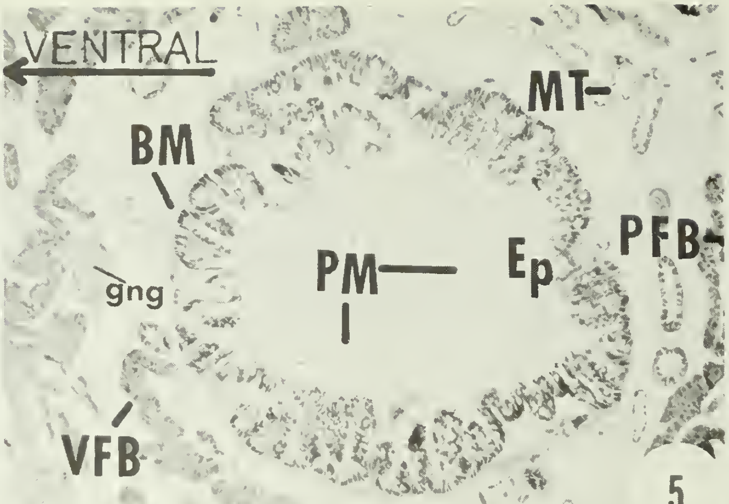

Figure 5. Transection through midgut tissues near anterior end, showing the characteristic folded structure. BM, basement membrane; Ep, epithelium; gng, ganglion, MT, Malpighian tubules; PFB, peripheral fat body; PM, peritrophic membrane; VFB, visceral fat body. Bar = 100 μm.

The vesicles emerge through the striated border, perhaps as a result of mechanical pressure induced by

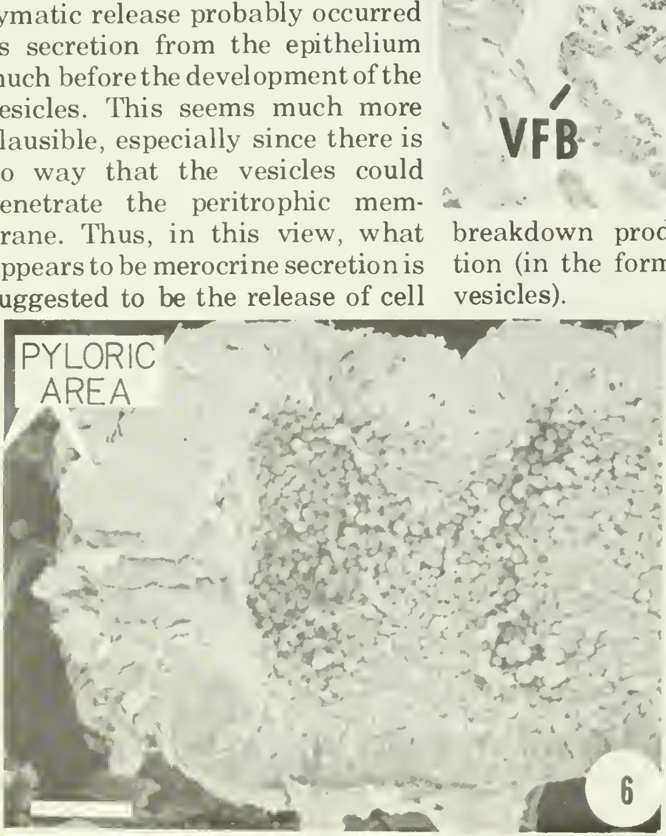

Figure 6. Sagittal section of midgut at the pyloric cone, showing a large number of extrusion vesicles as well as 2 shapes of midgut epithelial cells (elongate, lobed cells on right). Bar = 100 μm.

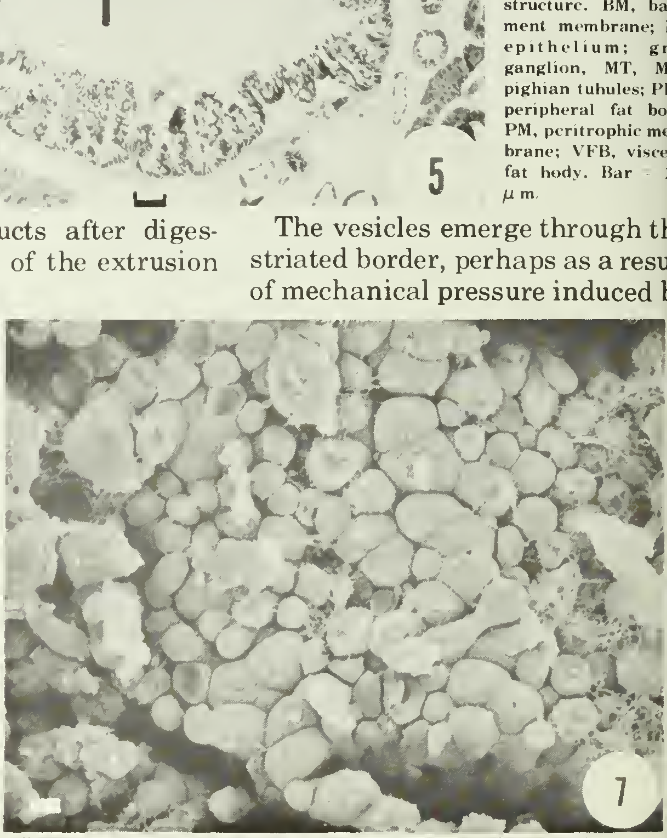

Figure 7. Close view of midgut epithelial surface showing extrusion vesicles, turgid and exploded cells, and surface debris. Bar = 10 μm.

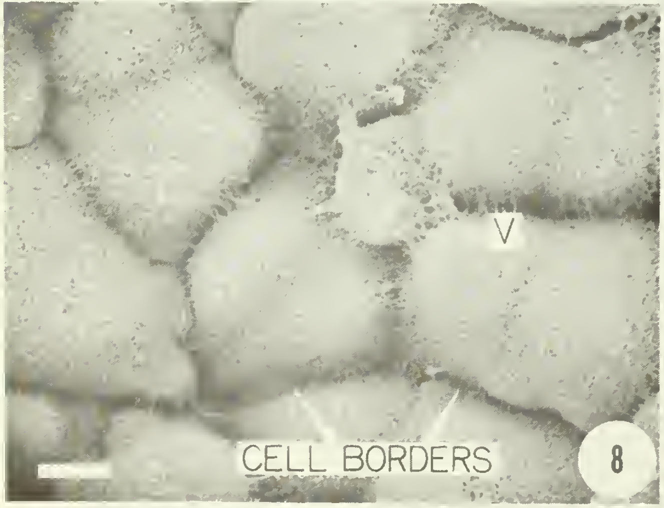

Figure 8. Enlarged view of epithelium showing a newly emerging extrusion vesicle (V.). Bar = 10 μm.

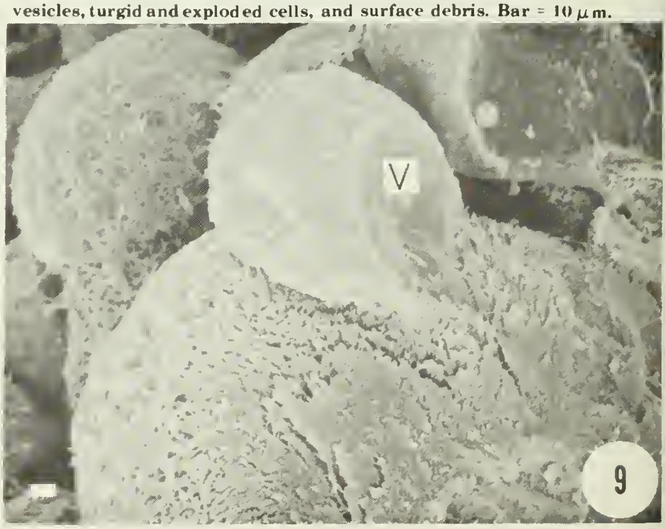

Figure 9. Extrusion vesicle protruding through the surface of an epithelial cell. These vesicles appear to be covered with a membrane upon emergence, although this was not demonstrated histologically. Bar = 1 μm.

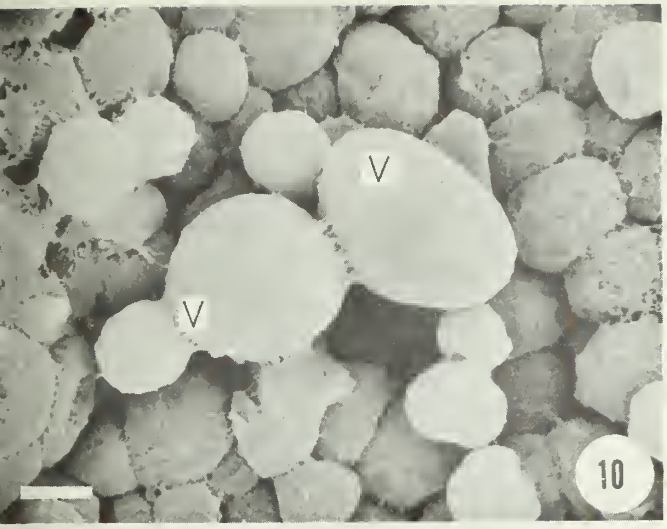

Figure 10. Coalescence of vesicles (V). Bar = 10 μm.

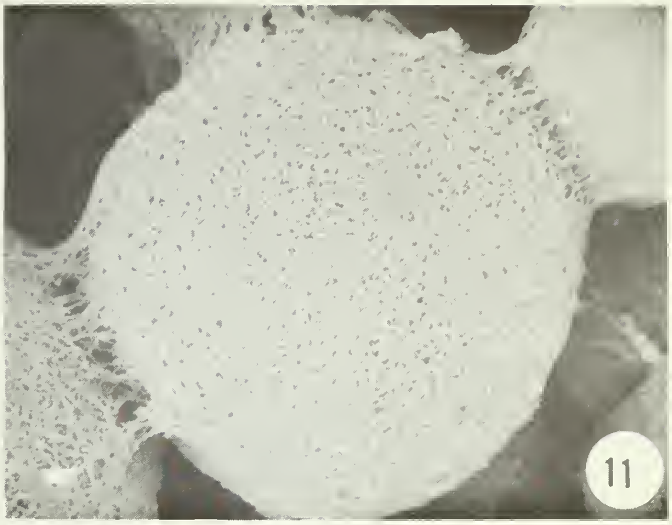

Figure 11. Spongy surface of mature, emerged vesicles, and coalescence. Bar = 1 μm.

regenerative cells below or because of changes in osmotic pressures. Tears are evident in the cell membranes as the vesicles enlarge (Fig. 9), and the vesicles completely emerging from the cell, appear to be enclosed in a membrane (not demonstrated by histology). At a later stage, the vesicles develop a spongy, mesh-like appearance, begin to coalesce with neighboring vesicles and cover the epithelial surface of the midgut (Figs. 10, 11).

Midgut and hindgut are separated at the posterior interstitial ring, which is composed of cuboidal epithelium like that of the anterior interstitial ring (Fig. 25). The ring merges into the intima and produces cells in the first plica of the pyloric cone (Fig. 18).

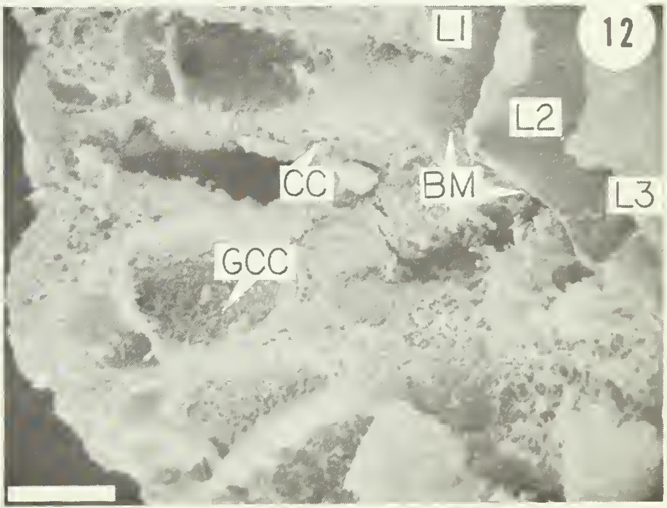

Figure 12. Goblet cells, with columnar cells tightly sandwiched between. Basement membrane separates into 3 lamellae (L1, L2, L3), the first appearing to be a condensation of the bases of the epithelial cells. Pores are seen through the tops of the goblet cells. Their function is not clear, but they may be associated with the extrusion vesicles seen in Fig. 13. CC, columnar cells; GCC, goblet cell cavity; BM, basement membrane. Bar 10 μm.

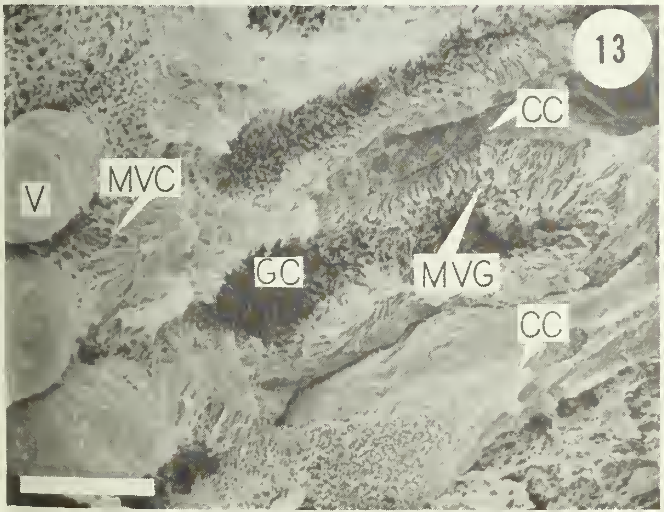

Figure 13. Goblet and columnar cells in SEM, with extrusion vesicles (V), CC, columnar cell; GC, goblet cell; MVC, microvilli of columnar cell; MVG, microvilli of goblet cell; V, vesicle. Bar = 10 μm.

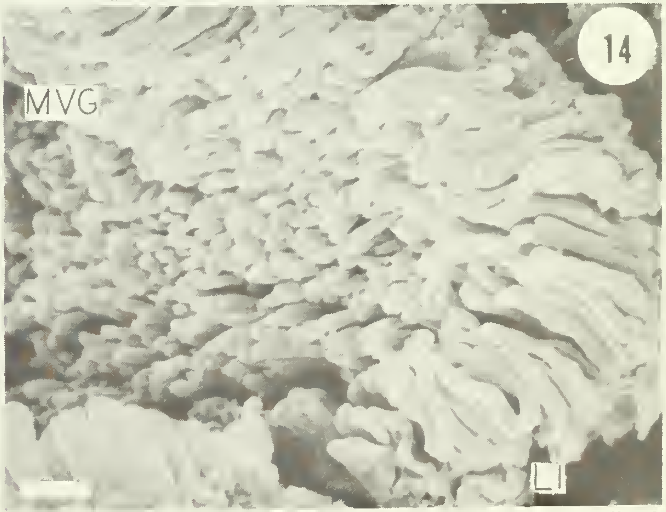

Figure 14. Close view of microvilli of goblet cell cavity. L1, 1st lamella of basement membrane; MVG, microvilli of goblet cell. Bar = [illegible] μm.

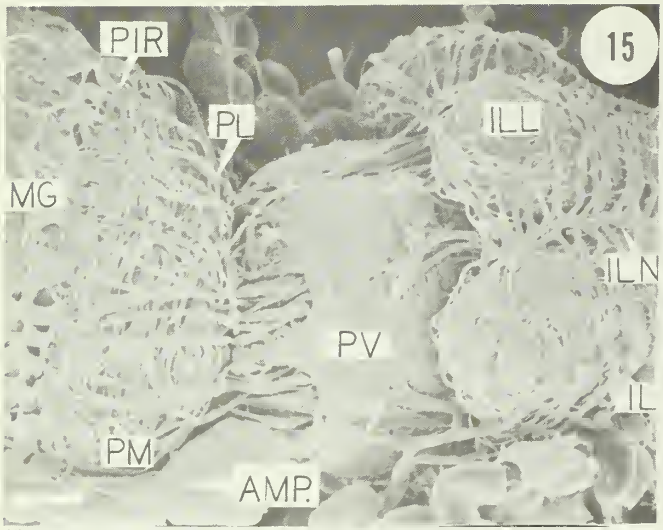

Figure 15. Pyloric region; dorsal view in SEM, showing orientation of the midgut, pyloric cone, pyloric valve, and ileum. Bar = 100 μ m. (See Fig. 16 for abbreviations).

Hindgut (Figs. 1, 15-23, 25-49)

Hindgut comprises the pyloric cone, pylorus, ileum, colon and rectum (Figs. 15-17). The pyloric area is by far more difficult to interpret than is any other area of the digestive system, because it may be distended or contracted so as to obscure some of its features. However, distinctive areas may be shown topographically. The hindgut is seen from the outside to originate at the posterior interstitial ring (PIR), indicated by a muscular halter (Fig. 15). The PIR marks the beginning of intima producing epithelium (Fig. 18,19). The area between the PIR and the tightly compressed anterior sphincter is the pyloric cone, which is covered by dense circular and longitudinal muscles. Posterior to this is a short pyloric valve. Overlying the pyloric value posteriorly are six ileolobes, which are large muscular extensions of the ileum that project forward over the base of the pyloric valve. The ileolobes terminate caudally in the ileum, closed by the posterior sphincter, which opens into the colon (Figs. 16, 17). The colon may be swollen or not, depending upon the presence of a fecal pellet, and opens into the anterior rectum by a muscular sphincter without internal differentiation.

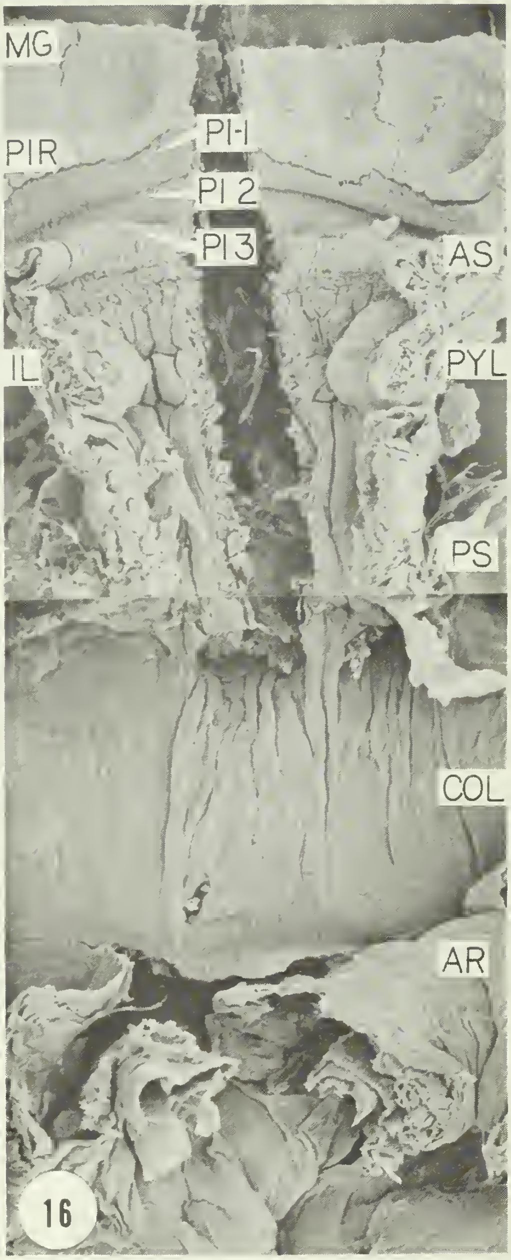

Figure 16. Pyloric region, ileum, colon and anterior rectum split longitudinally to show intern
organization. (Approx. same scale as Fig. 15). AR, anterior rectum; AS, anterior sphincter; CO
colon; IL, ileum; ILL, ileolobe; ILN, ileonode; MG, midgut; PIR, posterior interstitial ring; Pl-
1st plica; Pl-2, 2nd plica; Pl-3, 3rd plica; PM, pyloric cone circular muscles; P3, posteri
sphincter; PV, pyloric valve; PYL, pylorus.

Pylorus

The posterior interstitial ring immediately precedes the first plica of the pylorus. The cuboidal cells of the PIR (Fig. 25), when subjected to Feulgen reaction, gave results the same as those regressively stained by Gill hematoxylin-eosin.

Three major plicae follow the PIR and are identifiable by their spicules (Fig. 17). The first plic
bears transverse rows of caudall
projecting spicules (10 μ m long
0.2 μ m across the base), set withi
small folds of intima (Figs. 31, 32
Plica two bears sparse, caudall
directed spicules about 3 to 4 μ
long and 0.1 μ m across the bas
(Fig. 33) and merges into
wrinkled, third fold Pl-3, wit

parse spicules about 2 μm long nd 0.4 μm across the base. They re oriented caudad or cephalad epending on the wrinkles of the ntima (Fig. 34, 35).

Internal lobes project into the umen at the pyloric-ileal junction, nd consist of clusters of epithelial ells covered with a thick, spiny ntima (Figs. 17, 20, 36, 37). These obes are unusual because the picules point forward toward the ylorus. Each lobe is composed of ubunits of two to three cells that orm smaller lobes (Fig. 20). The pithelium consists of large cells, 100 to 130 μm-long, that contain longate to lobed nuclei. Short, transverse bundles of muscle fibers ccur between the smaller lobes. Cell membranes are usually indistinct. The deep, spiny intima appears to shred the peritrophic membrane as it passes into the ileum (Figs. 21, 37).

leum

The ileum consists of six ileolobes, which are large extensions of the ileum that project forward over the pyloric valve anteriorly, and a narrower neck that opens into the colon via the posterior sphincter (Fig. 17). The intima consists of thick oval humps protruding into the lumen at the ilelobes, longitudinally folded intima of the neck or tubular region (Fig. 38) and caudally directed spicules of the posterior sphincter (Fig. 39).

Internal nodes in each ileolobe occur in apposition to each other (Figs. 22, 23). Circular muscles occur between the ileum and ileolobe, and a ring of circular muscle enevelops both. Epithelial cells have indistinct cell membranes and small rounded nuclei. Ileonodes have giant epithelial cells in the apical region and smaller cells basally (Fig. 22). Intima of the lobes, nodes and ileum are variable in thickness --- thin and imperceptible in some

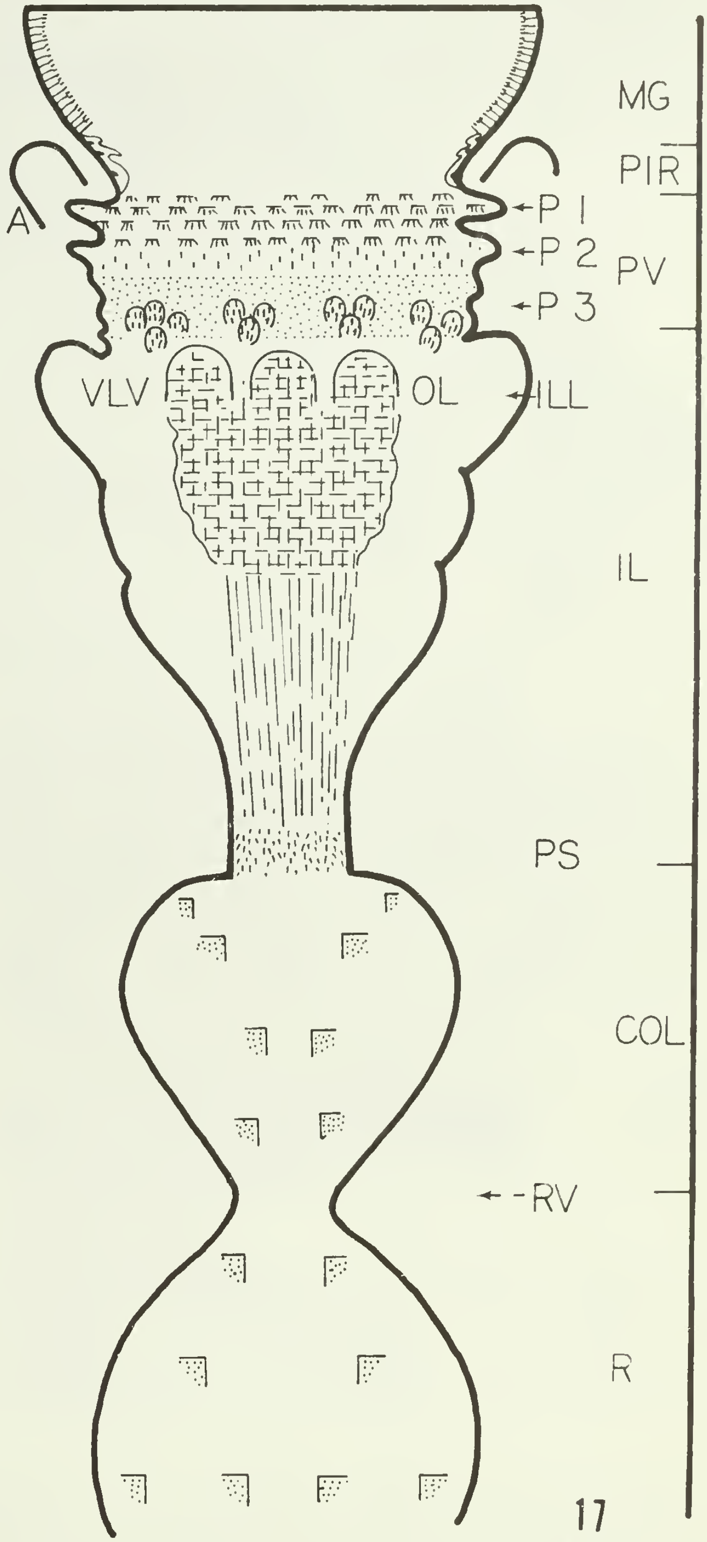

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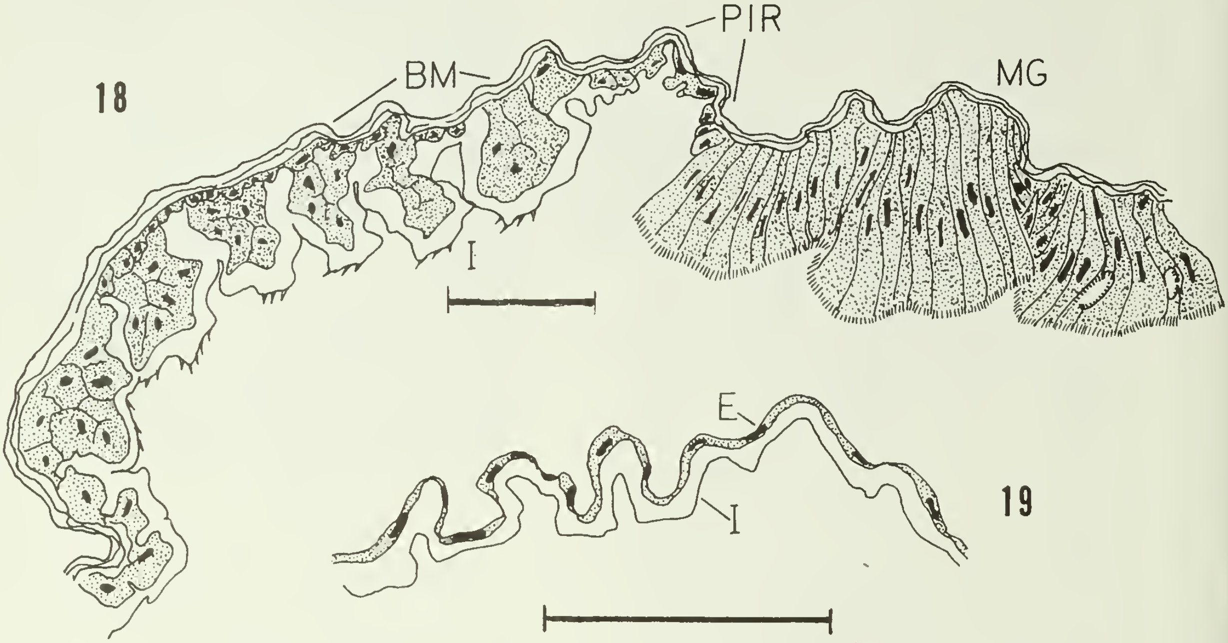
Figure 17. Diagrammatic map of hindgut topography. A, Ampulla of Malpighian tubules; COL, colon; IL, ileum; ILL, illeolobe; MG, midgut; OL, occluding lobe of ileum; P-1, 1st plica of pyloric cone; P-2, 2nd plica of pyloric cone; P-3, 3rd plica of pyloric cone; PIR, posterior interstitial ring; PS, posterior sphincter of ileum; PV, pyloric valve; R, rectum: RV, rectal valve; VLV, valvulae of anterior sphincter (Pl-3) of pylorus.



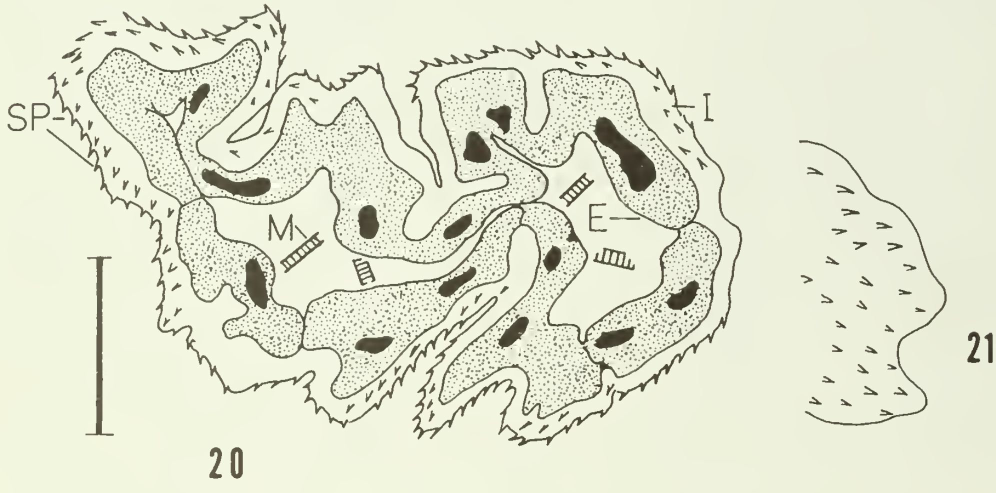
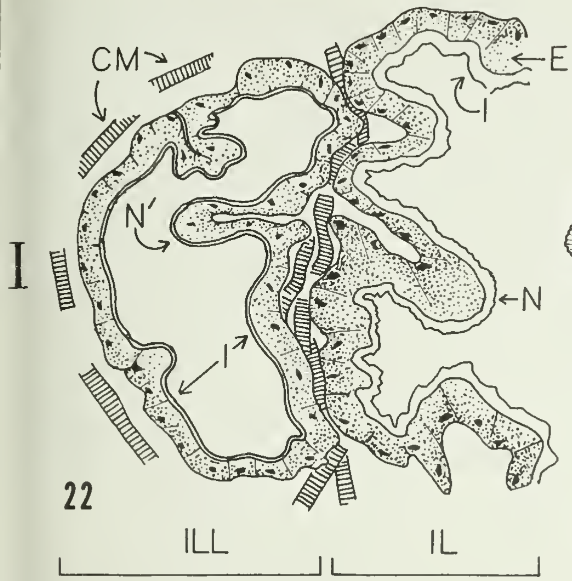


Figure 18. Diagrammatic longitudinal section at junction of midgut and hindgut, marked by posterior interstitial ring. First plica of pylorus with caudally directed spicules succeeds the ring. BM, basement membrane; I, intima; Mg, midgut; PIR, posterior interstitial ring. Bar - 100 μm. Figure 19. Close view of intima producing ring. Bar - 100 μm.

Figure 20. Transverse section through valvula of pyloric-ileal junction; 2- cells form subunits of the valvulae; epithelium with very large cells, indistir borders, large, lobed nuclei and thick, spiny intima. I, intima; E, epithelia cell; M, muscle; SP, spicules. Bar - 100 μm. Figure 21. Inset-enlargement c intima in Fig. 20.

specimens, very thick and fluted in others. Thick, fluted epithelium occur in the enlargement of apposed ileonodes (Fig. 23). Paired tracheae occur at the junction of the ileonodes and ileum. Other authors have noted that ileonodes similar to these occur between the ileolobes --- i.e., the depression occurring between the enlarged nodes (Fig. 15). The nodes in *H. zea* occur within as well as between lobes and, in the lobed and tubular regions of the ileum. Spiculate lobes at the pyloric-ileal junction of the intima of Pl-3 may be found farther back into the ileum if th gut is distended (full) or at th posterior margin if withdraw (empty); therefore, the true origin c the ileum may not at first b evident. The valvulae themselve can be interpreted as marking th origin of the ileum internally.



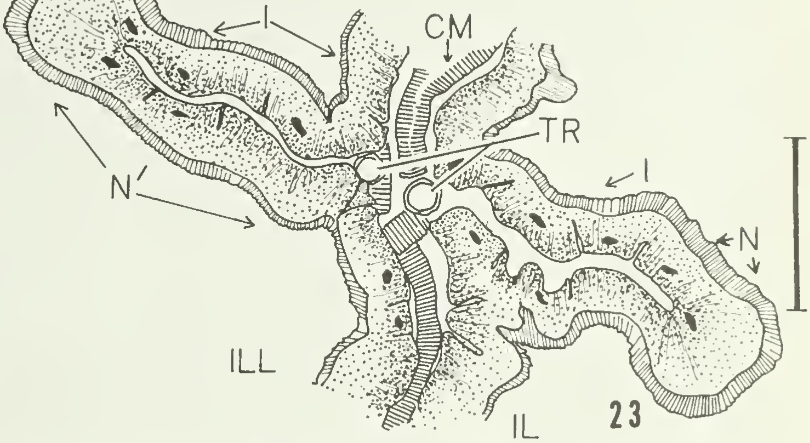
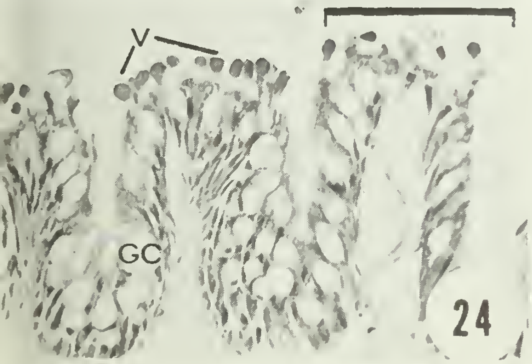
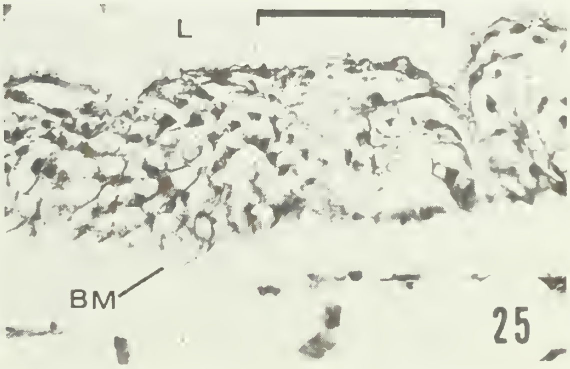
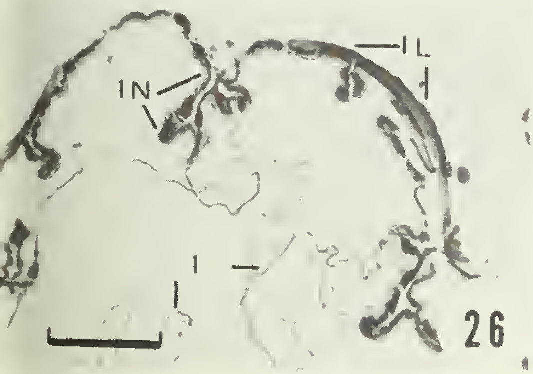


Figure 22. Transection of ileum and one ileolobe. Nodes (N, N′) project into the lumen of the ileum and ileolobe. The intima of such nodes varies from very thin to thick and fluted. Epithelial cell borders are for the most part obliterated, and giant cells occur toward the apex of the nodes. CM, circular muscle; E, epithelium; I, intima; N,N′, nodes of ileum. Bar = 100 μm. Figure 23. Enlargement of the nodes (N,N′) projecting into the lumen of the ileum and ileolobe. The large "giant cells" occur near the apex. Intima may have a deeply fluted appearance over these nodes, less so over the rest of the epithelium. CM, circular muscle; ILL, ileolobe; N, node of ileum; N′, node of ileolobe; TR, tracheae. Bar = 100 μm.







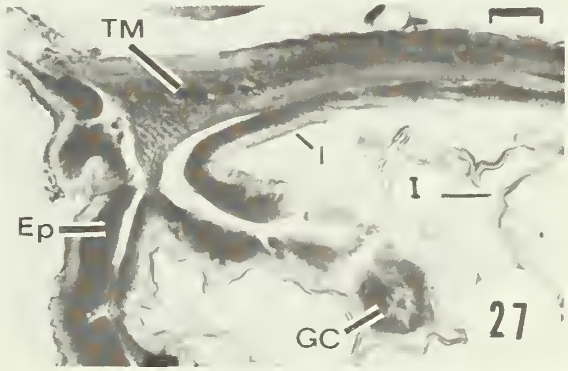
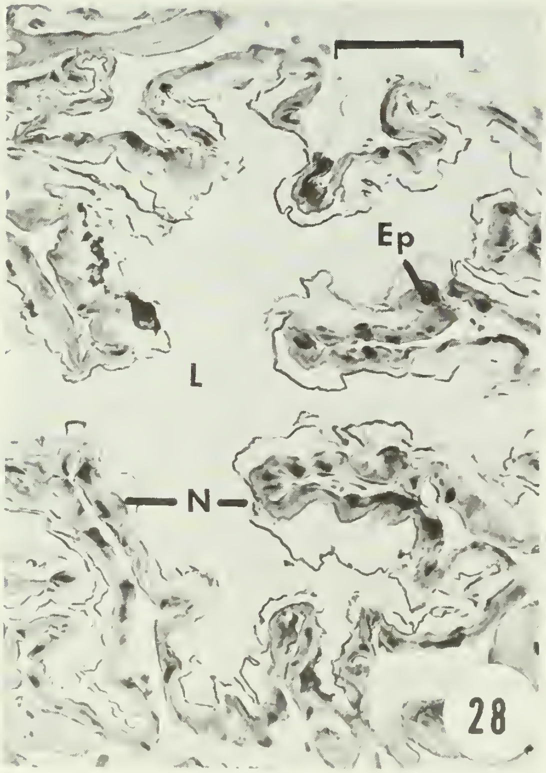
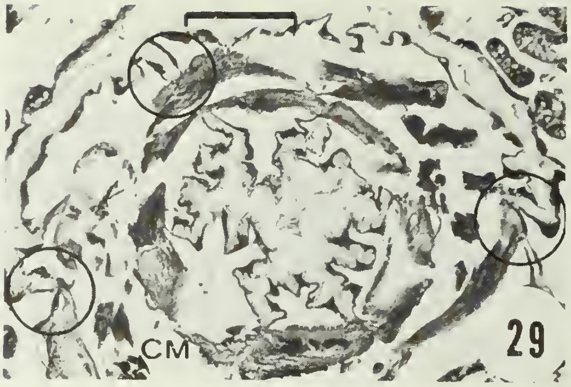


Figure 24. Folds of midgut epithelium showing extrusion vesicles; vesicles stain heavily with Gill hematoxylin but give negative Feulgen reaction. GC, goblet cavity; V, vesicles. Bar = 70 μm. Figure 25. Transection through posterior interstitial ring (PIR). AIR is essentially the same. BM, basement membrane; L, lumen. Bar = 70 μm. Figure 26. Ileolobes and nodes, transection through ileum. IL, ileolobe; IN, ileonode; I, intima. Bar = 100 μm. Figure 27. Attachment of transverse muscles to epithelium of the ileonodes and adjacent lobes. Ep, epithelium; GC, giant cell; I, intima; TM, transverse muscle. Bar = 10 μm.

Colon

The ileum empties into the colon via the posterior sphincter, a short series of cells with caudally projecting spicules (Fig. 39). The colon is distinguishable by the epicuticular depressions, made up of minute crater like impressions of the intima that are visible at 4000 X or more (Figs. 46-48). The intima of the colon, rectum and anal membranes is entirely and finely dotted with these structures. The epicuticular depressions in certain specimens appear to be perforations (Fig. 48), but in others appear to be closed and very uniform in size and shape.





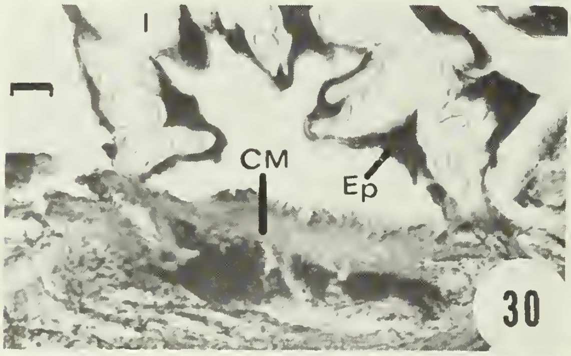
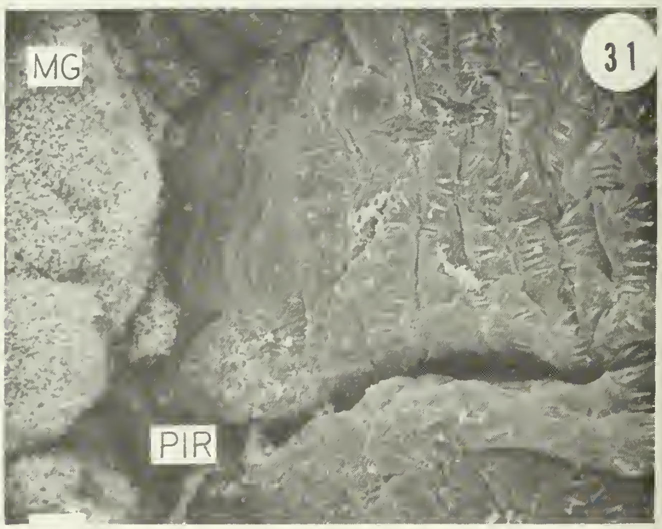


Figure 28. Higher magnification of ileal cross section from Fig. 26, with thick intima, numerous secondary infoldings. Ep, epithelium; L, lumen; N, nodes of ileum. Bar = ca. 50 μm. Figure 29. Cross section of colon at hinge points of perinephric membrane. Colon epithelium attaches at 6 distinct points to the circular muscle, preserving the 6-lobed pattern of the anterior ileum. Encircled areas show hinges of membranes of cryptonephridic system. CM, circular muscle. Bar = 100 μm. Figure 30. Close up of attachment of colon epithelium to transverse muscle. Intima is produced to displace epithelial cells, forming a stout bond to muscle. Ep, epithelium; CM, circular muscle. Bar = 10 μm.



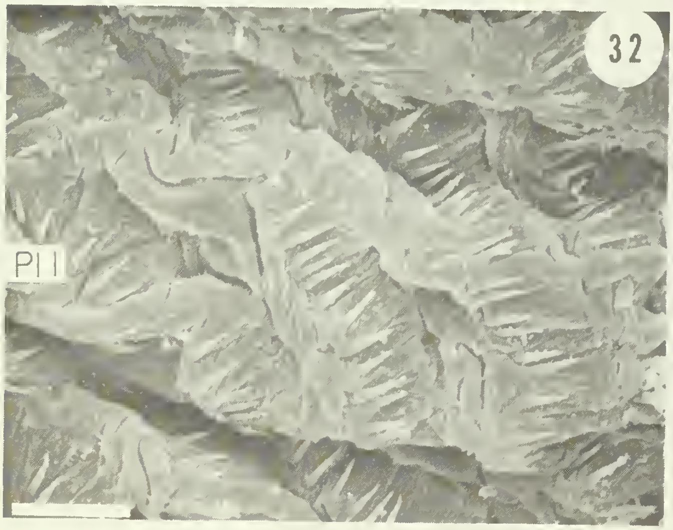
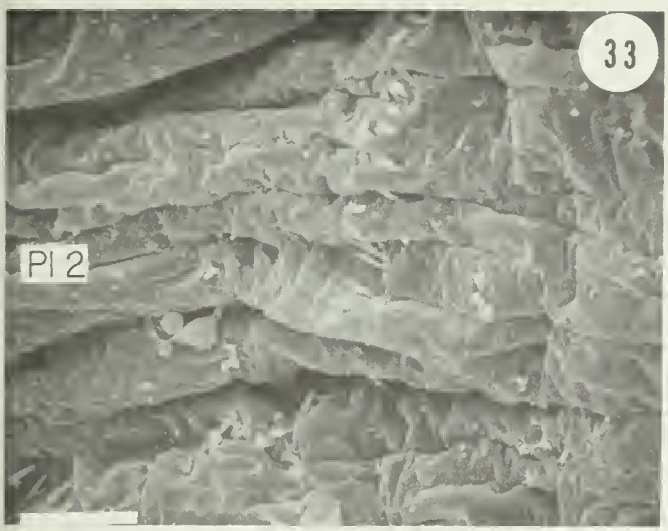
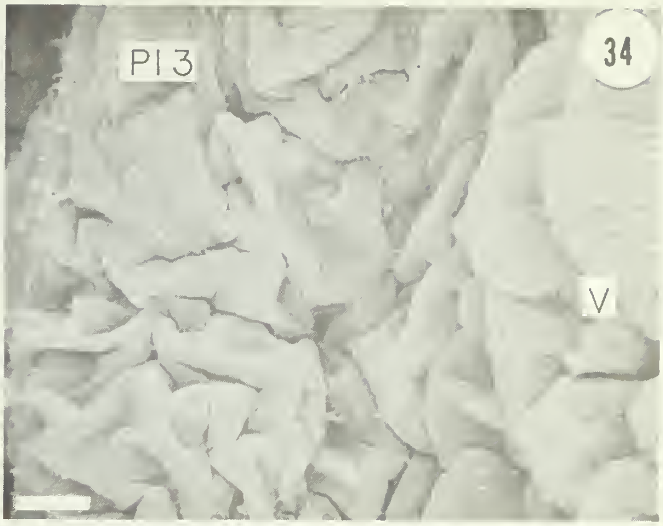


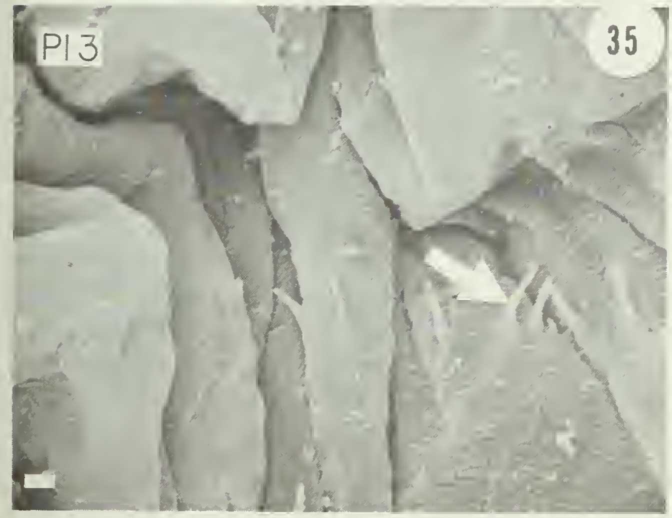
Figure 31. Juncture of midgut and 1st plica of pyloric cone, with backward projecting setulae and deeply infolded PIR. MG, midgut; PIR, posterior interstitial ring (infolding of surface). Bar = 10 μm. Figure 32. Enlargement of 1st plica of pyloric cone, PL-1. Bar = 10 μm.

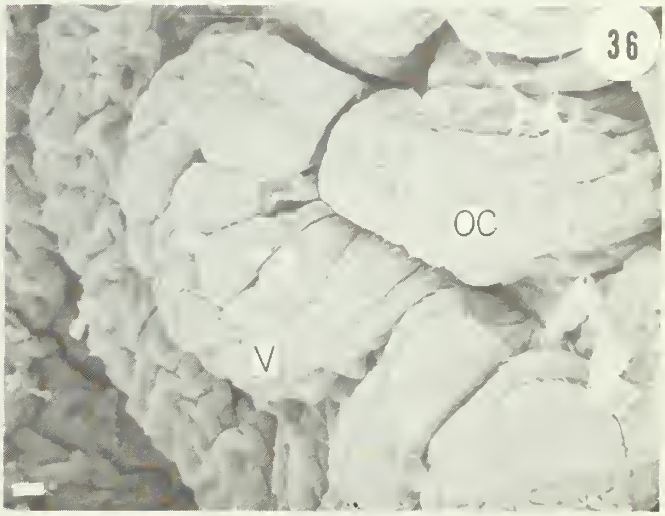
Rectum

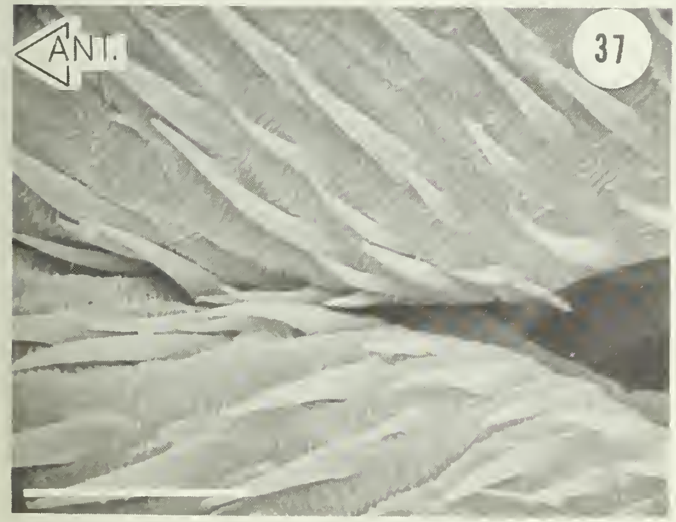
The colon (Figs. 29, 30, 40-45) empties into the anterior rectum through a simple muscular sphincter, the rectal valve, without differentiation of the intima. Anterior rectum is identifiable by the cryptonephridial arrangement of the Malpighian tubules, i.e., a double layer of tubules in the anterior rectum and no tubules in the posterior. The anal region maintains the six-plicate pattern of the remainder of the hindgut (Fig. 49) and is dotted with epicuticular depressions.











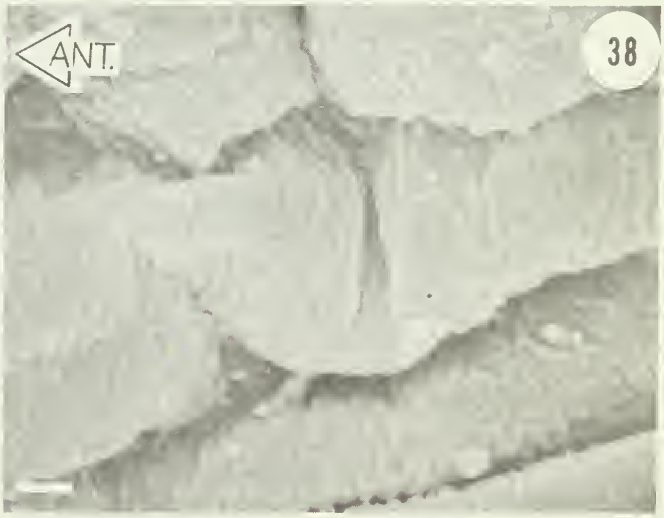


Figure 33. Second plica of pyloric cone, with sparse setulae. Bar = 10 μ m. Figure 34. Third plica and valvulae (V) of pyloric cone. Valvulae belong to the anterior sphincter of the pylorus. Bar = 10 μ m. Figure 35. Enlarged view of setulae of 3rd plica (Pl-3). Bar = 1 μ m. Figure 36. Third plica, merging with valvulae (V) and occluding lobes (OC) of the anterior sphincter. The latter two structures occur at the beginning of the ileum. Bar = 10 μ m.

Figure 37. Spicules of the valvulae found at the pyloric-ileal junction. The setulae project cephalad. Bar = 10 μm. Figure 38. Post valvular intima of epithelium, consisting of blocky to convoluted texture, creased longitudinally. Bar = 1 μ m.

Malpighian tubules

Malpighian tubules originate at the pylorus as two ampullae, one on either side and each with a major branch that divides into three elongate tubules. The six tubules progress forward 1/2 to 2/3 the distance of the midgut, turn and run back to the ileum, then become highly convoluted over the ileum and closely packed in a mass known as the iliac plexus. They emerge from this, and two enter the anterior rectum dorsally, two laterally and two ventrally, progress caudad to the posterior rectum, then through a double membrane, turn and proceed cephalad, then bend again caudally. The cryptonephridial system of *H. zea* conforms to that described by Saini (1964). The rectal chamber may be either collapsed (Figs. 40, 44) or distended (Figs. 41, 45) bu shows the cryptonephridial system most clearly when distended.

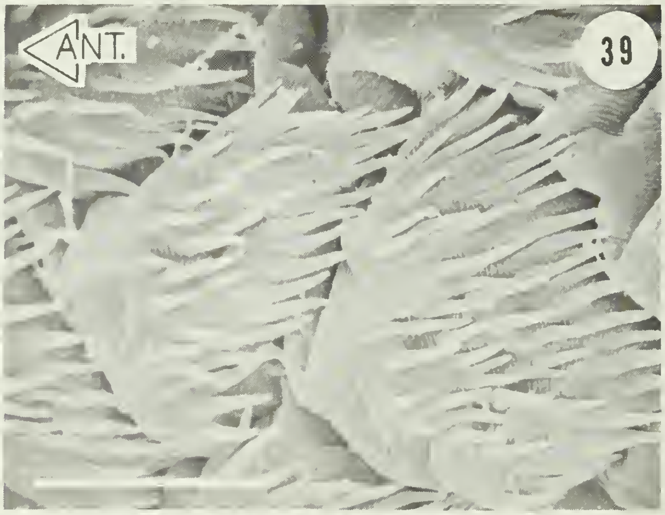
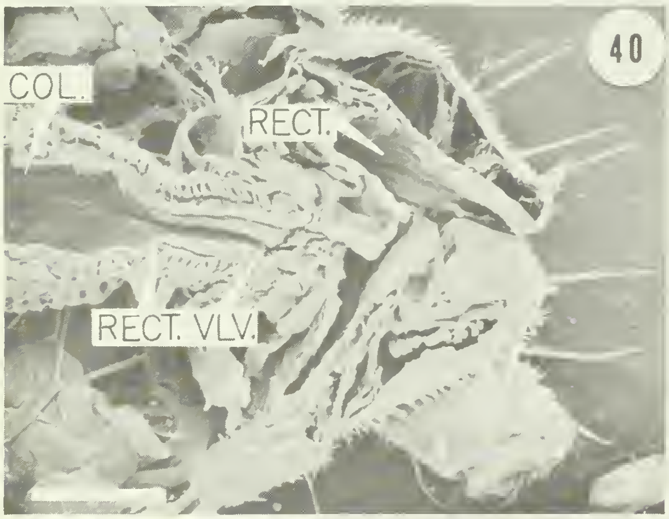
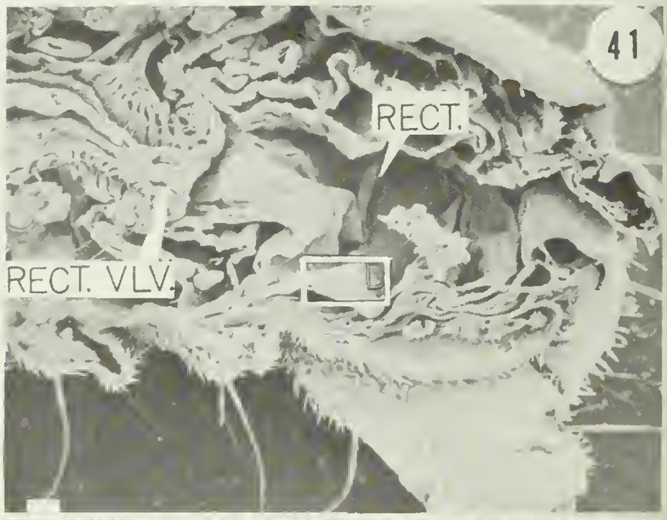
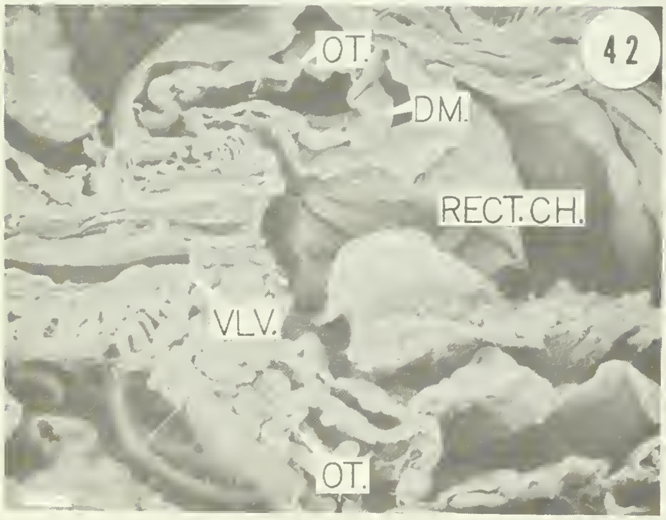


Figure 39. Posterior ileal sphincter, with caudally directed setulae forming a narrow band around the ileo-colon junction. Bar = 10 µm.







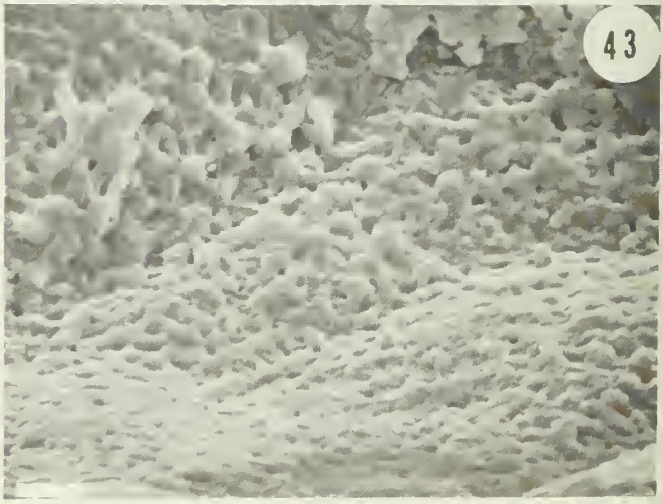
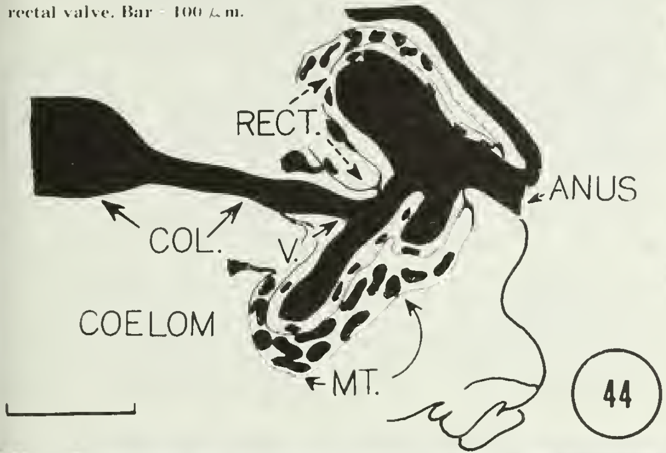


Figure 40. Sagittal section through the anal segments of late instar larva, the rectal chamber collapsed. COL, colon; RECT, rectum; RECT VLV, rectal valve. Bar = 1 mm. Figure 41. Similar section, with rectal chamber distended. RECT, rectum; RECT VLV, rectal valve. Bar = 100 . Inset is area shown in Fig. 43.

Figure 42. Close view of rectal valve, chamber, and cryptonephridic tubules. DM, double membrane separating inner and outer Malpighian tubules (inner tubules do not appear in this photo); OT, outer tubules; RECT CH, rectal chamber; VLV, rectal valve. Bar = 100 µm. Figure 43. Enlarged view of intima of rectal chamber, with irregular surface sculpture, and small micropores sprinkled over the surface. Bar = 1 µm.

Figure 44. Diagrammatic version of anal associations, with the colon collapsed. COL, colon; RECT, rectum; MT, malpighian tubules of the cryptonephridic system. Bar = 1 mm. Figure 45. Diagrammatic section of anal associations with the rectal chamber distended. RECT, rectum; V, rectal valve. Bar = 100 µm.



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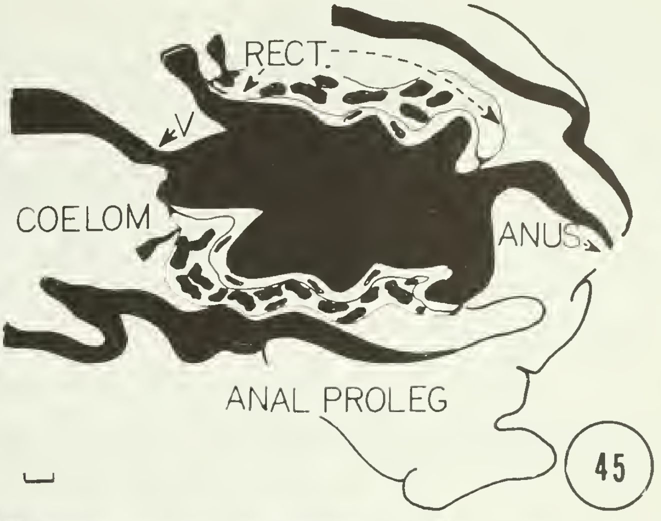

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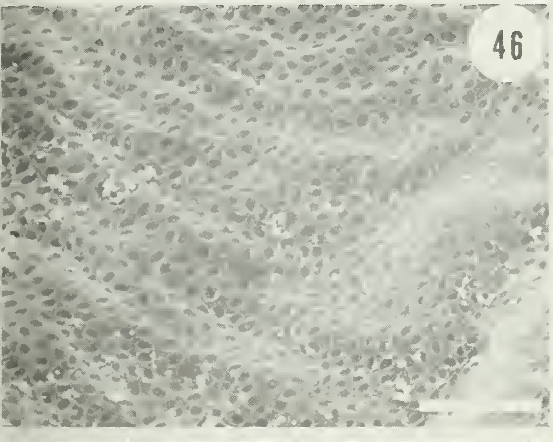

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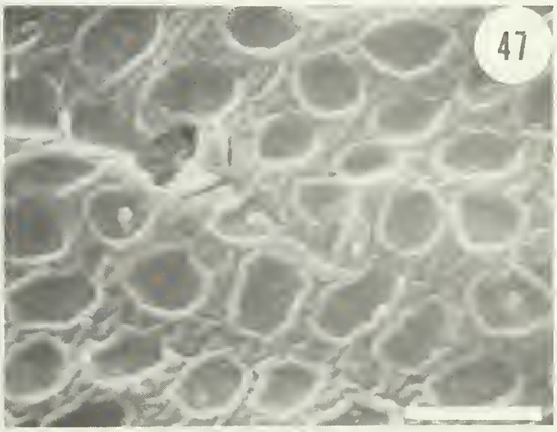

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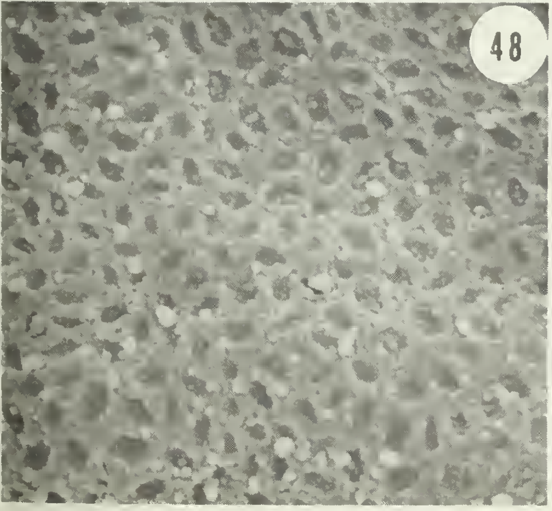

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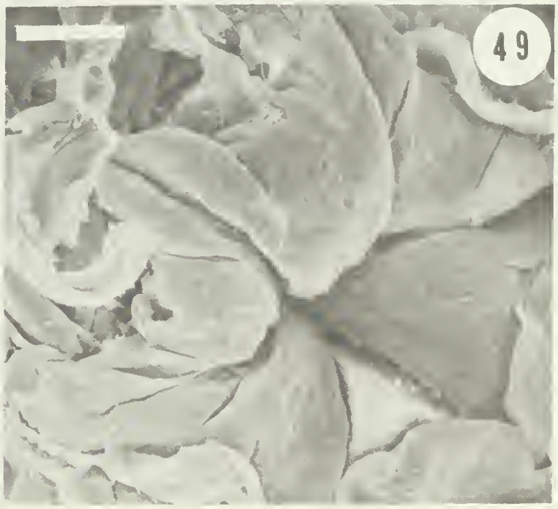

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Figure 46. Epicuticular depressions of rectal intima at relatively low magnification (original at 4000X), depressions of ca. 1/2- 3/4 µm. densely scattered over the surface of the rectum, as well as the colon. Bar = 5 µm. Figure 47. Enlarged view of epicuticular depressions (original at 22300 X). Bar = 1 µm. Figure 48. View of epicuticular depressions, appearing as circular to oval pits, the borders and intervening areas granulate. Bar = 1 µm. Figure 49. External view of anal membranes, preserving roughly the 6-plicate pattern found throughout the hindgut. Anal membrane also bears the epicuticular depressions found in rectal intima. Bar = 100 µm.

Silk Glands and Salivary Glands (Figs. 50-55)

The large white silk glands (Figs. 50-55) are evident immediately upon opening the larvae. These originate at the silk press as fine ducts that lead to larger accessory glands (glands of Filippi, Fig. 54) that unite with the silk gland duct by two lateral channels. Silk glands are composed of an inner and outer duct throughout their length. The glands of Filippi have no distinct cell membranes and a diffuse nuclear material. The silk glands then progress caudad, fold beneath the crop and midgut and reemerge at about the middle of the midgut. The glands then form a sigmoid curve and terminate free in the coelom.

H. zea possesses a pair of small mandibular salivary glands (Fig. 1) as well as the silk glands. These extend to either side of the foregut as transparent cones and narrow to very fine ducts beneath those of the silk glands.

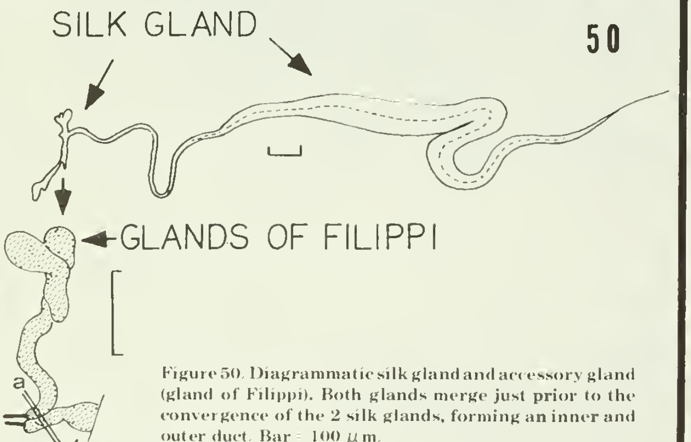

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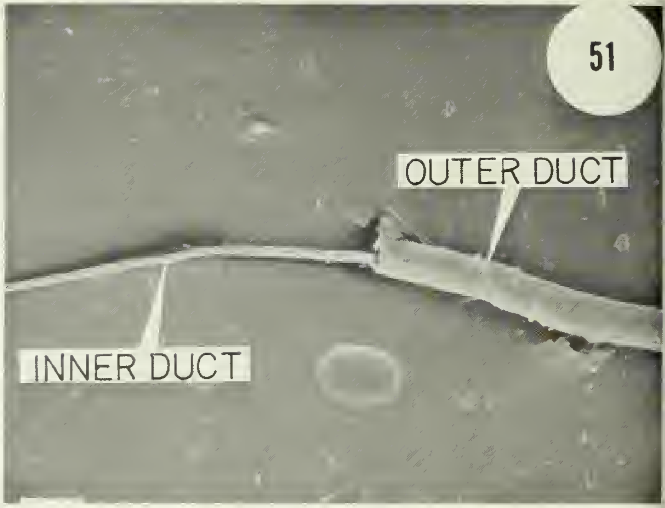
Figure 50. Diagrammatic silk gland and accessory gland (gland of Filippi). Both glands merge just prior to the convergence of the 2 silk glands, forming an inner and outer duct. Bar = 100 μm.



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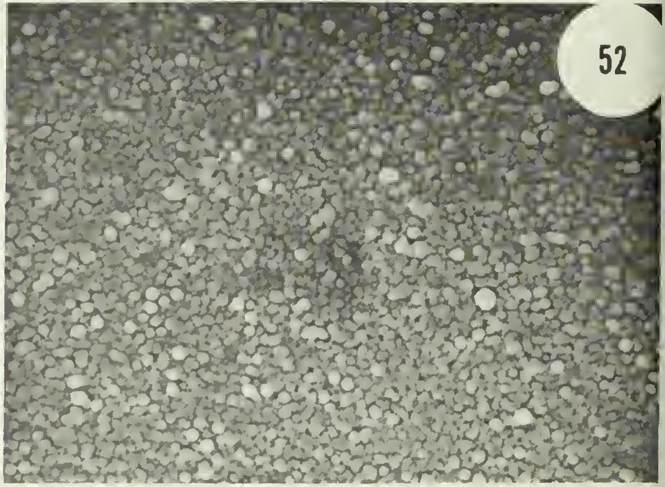

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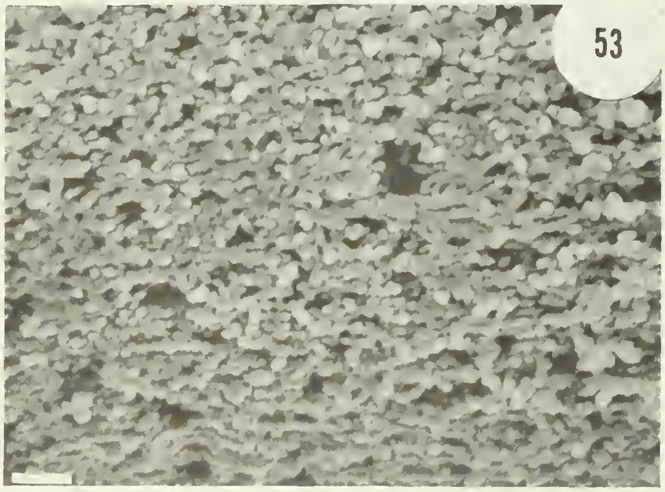

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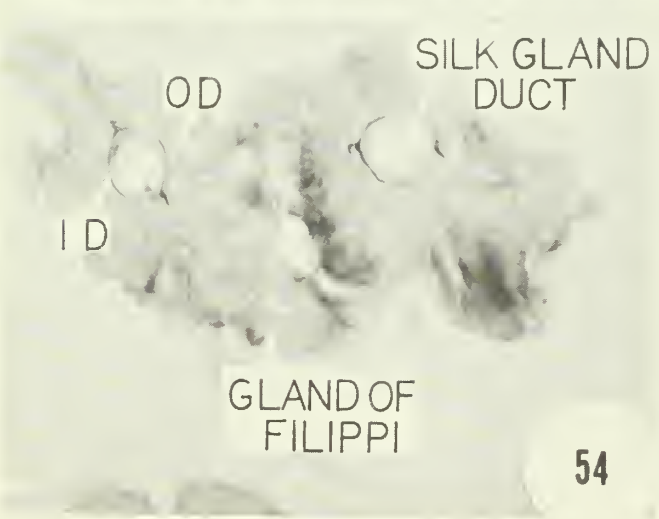

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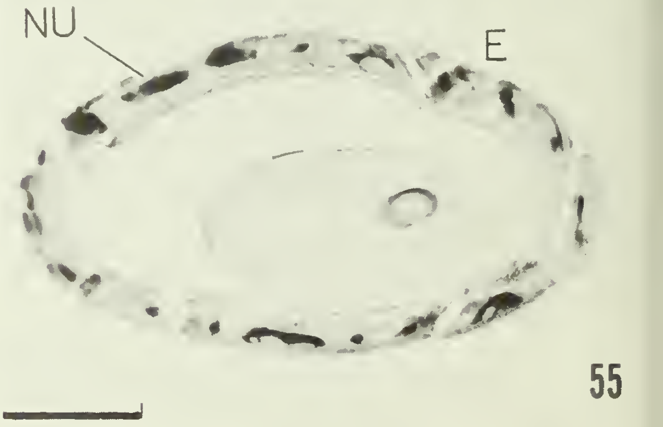

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Figure 51. An inner duct or sheath runs through the outer main sheath of the silk gland. Bar = 100 μm. Figure 52. Topography of outer surface of inner sheath, showing a very finely granular surface at high magnification (original magnification 10,000 X). Bar = 1 μm. Figure 53. Coarser granularity of the surface of the outer sheath of the silk gland. This sheath has a cellular component, whereas the inner duct appears to be filled with viscid material. Bar = 1 μm. Figure 54. Cross section of silk gland conjoined with glands of Filippi, showing double walled tube. ID, inner duct; OD, outer duct. The section corresponds to a-a' of Fig. 50. The glandular aspect appears more or less amorphous, without true nuclear component or cell walls. Bar = 20 μm. Figure 55. Transverse section of silk gland, with inner, viscid mass, outer epithelium. NU, branched, elongate, or lobed nuclei characteristics of silk glands; E, epithelium.

Discussion

Several excellent papers have eported on the digestive systems f various lepidopterous larvae. ur study was not principally omparative, but certain observations can be related to those nade on other species.

Judy and Gilbert (1970) reported pecific dimensions for thickness f the foregut and hindgut intima f *Hyalophora cecropia.* We found his character to be quite variable. here may, however, be a terminal hickness in each instar. Measurenents of intima thickness are very usceptible to nuances of sectioning because the intima is pulled asily from the underlying pithelium. Cell size also seems uite variable and often difficult to measure accurately because the cell membranes in fore and hindgut usually are obscure, even in well prepared specimens. Giant cells reported in the ileonodes may sometimes resolve into six or more smaller cells, but the apical cell usually is larger. Judy and Gilbert pointed out that the extrusion vesicles had cytoplasmic staining properties. This was true also of *H. zea.*

Anatomy of the hindgut is the most difficult to interpret, but the difficulty is resolved by using topographic information. Our observations on hindgut anatomy differ little from those of Reinecke et al (1973) for *Manduca sexta* or from Judy and Gilbert (1969-1970), but differ from the review by Byers and Bond (1971) because we recognize the ileum, which appears to be incorporated into the pylorus as they interpreted it. Also, the spicules of pyloric Pl-2 in *H. zea* are not hooked but are simply pointed, which may be a difference due to species. There is general agreement among these authors that the epicuticular depressions occur in the colon as well as in the rectum. However, none suggest that the depressions originate as micropores, as our photos show for both *Heliothis zea* and the boll weevil, *Anthonomus grandis* Boheman (MacGown and Sikorowski 1980).

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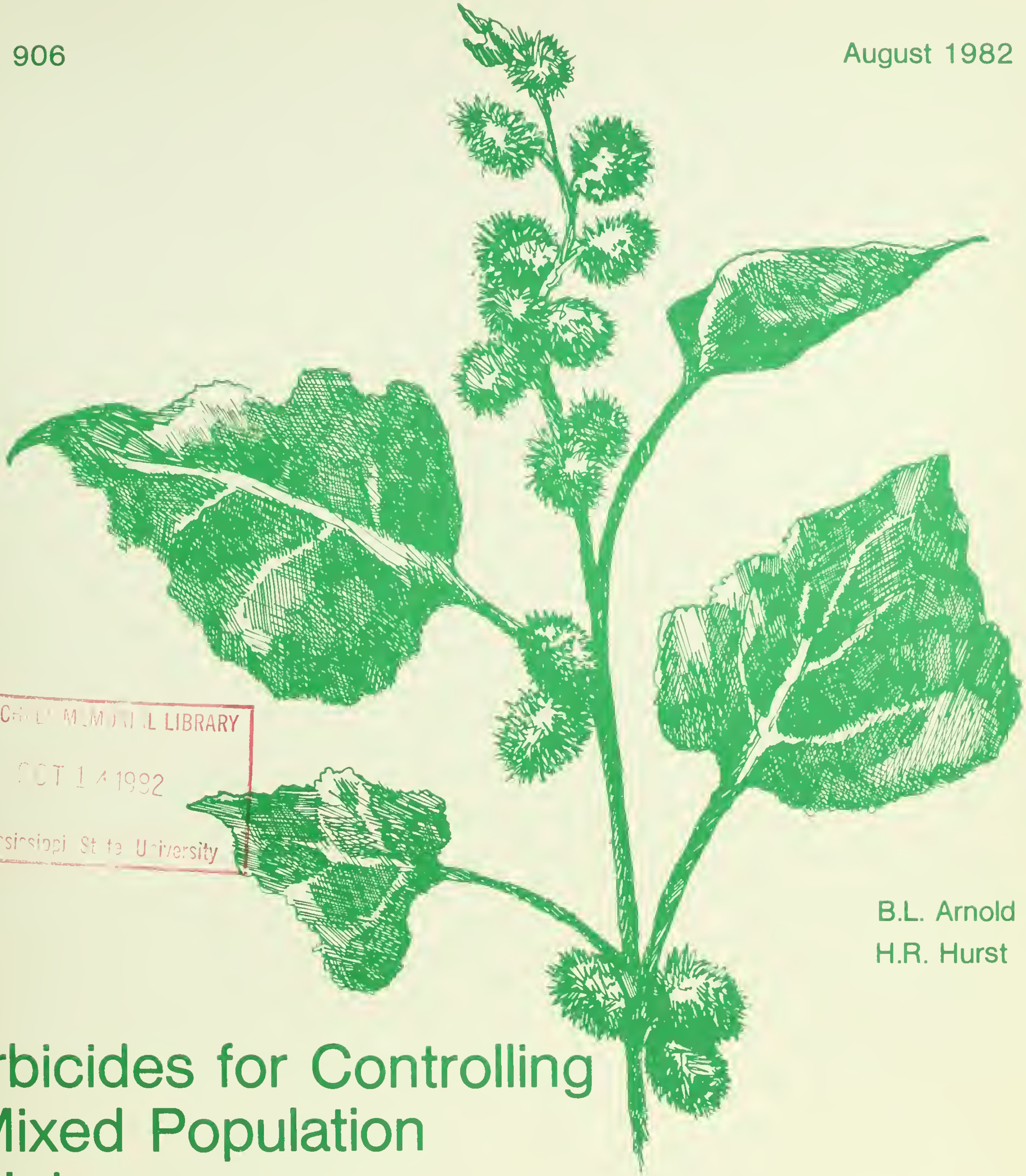

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Herbicides for Controlling a Mixed Population of Johnsongrass and Common Cocklebur in Soybeans.

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Herbicides for Controlling a Mixed Population of Johnsongrass and Common Cocklebur in Soybeans.

Herbicides for Controlling a Mixed Population of Johnsongrass and Common Cocklebur in Soybeans.

Johnsongrass [*Sorghum halepense* (L.) Pers.] and common cocklebur (*Xanthium pennsylvan-cum* Wallr.) are common problem weeds in soybean [*Glycine max* (L.) Merr.] fields (2,3). Dinitroaniline herbicides applied preplant at twice the rate (2X) labeled for annual grass control and glyphosate applied with the recirculating sprayer (RCS) have improved the control of rhizome johnsongrass in soybean fields (1,4). Applications of dinoseb, bentazon and mixtures of dinoseb and naptalam also have reduced common cocklebur in many fields, and the weed now can be controlled more effectively.

We report in this publication the results of a study of the effectiveness of selected herbicides for control of large, natural infestations of johnsongrass and common cocklebur in soybean fields.

Method and Materials

The three-year trial (1977-79) was conducted at the MAFES North Mississippi Branch on a silt loam soil (17.6% sand, 68.8% silt, 13.6% clay) with 1.4% organic matter and pH of 6.1. The design was a split plot with four replications.

Main plots were 16 rows (40 inches wide and 30 ft long), and the treatments were a check (no preplant herbicide) and preplant incorporated treatment with fluchloralin, profluralin, trifluralin or pendimethalin for johnsongrass control (Table 1). Each herbicide was broadcast at the 2x rate in fall 1976 and 1977 and incorporated by

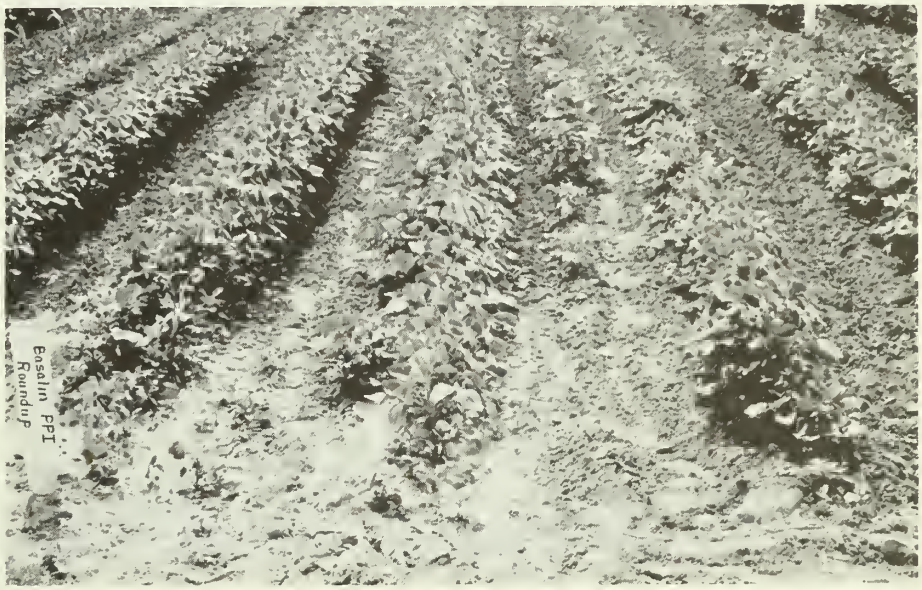

Figure 1. BASALIN 1.5 lb/A 1976, 1977 Fall +0.75 lb/A 1979 Spring Preplant Incorporated. ROUNDUP in recirculating sprayer in mid-summer of 1977, 1978. Shows excellent control of Johnsongrass and no control of Cocklebur. Picture - July 17, 1979.

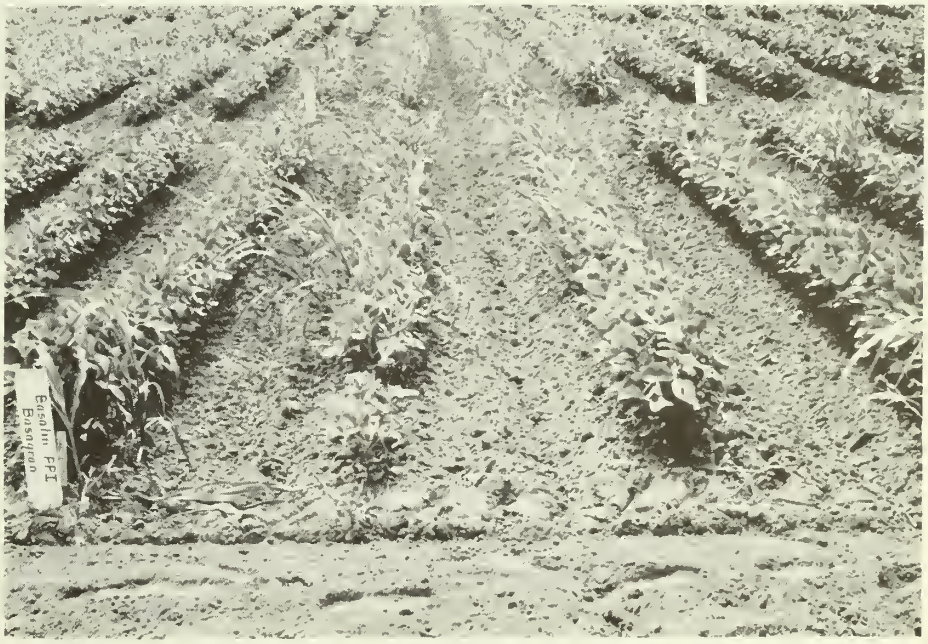

Figure 2. BASALIN (same as in 1 above). BASAGRAN 0.75 lb/A over-the-top early-season 1977, 1978, 1979 and repeated if needed. Shows fair control of Johnsongrass and excellent control of Cocklebur. Picture - July 17, 1979.

disking twice soon thereafter, and beds were formed in March 1977 and 1978. Bedded rows were prepared in 1979 before applying each herbicide and incorporating 2 inches deep with a power-driven rotary tiller. Each main plot received the same preplant treatment each year.

Subplots were four 40-inch wide by 30-ft long rows on each main plot, and treatments were postplant herbicide applications. T
postplant herbicides were appli
either singly or in sequenti
programs for control of johnso
grass and/or cocklebur (Table 1

'Forrest' soybeans were plant

Table 1. Preplant treatment with superimposed postplant treatments for control of common cocklebur and johnsongrass in soybeans in herbicide trials at the MAFES North Mississippi Branch, 1977-79.

Main Plot Preplant Treatments				Postplant Treatments of Each Main Plot					
	lbs ai/	Broadcast and incorporated			lbs ai/				
Herbicides	acre	Date	Method	Herbicides	acre	Date	Method	Weed	Stage
		Fall 1976				1977			
A. Fluchloralin (Basalin 4E)	1.50	11-5	Disk harrow 4 inches deep	a. Metriflufen + surfactant (HOE 29152 3E)	0.75	6-10	OT[1]	JG[3]	12-15"
B. Profluralin (Tolban 4E)	1.50	11-5	Disk harrow 4 inches deep	b. Bentazon (Basagran 4E)	0.75	6-10	OT	CB[4]	3-5"
				Chlordimedon (BAS 9021 75W)	1.00	6-20	OT	JG	12-15"
				Bentazon	0.75	6-29	OT	CB	10-15"
C. Trifluralin (Treflan 4E)	1.50	11-5	Disk harrow 4 inches deep	c. Bentazon	0.75	6-10	OT	CB	3-5"
				Metriflufen + surfactant	0.75	6-20	OT	JG	12-15"
				Bentazon	0.75	6-29	OT	CB	10-15"
D. Pendimethalin (Prowl 4E)	1.50	11-5	Disk harrow 4 inches deep	d. Bentazon	0.75	6-10	OT	CB	3-5"
				Bentazon	0.75	6-29	OT	CB	10-15"
E. None (check)	--	--	---						
		Fall 1977				1978			
A. Fluchloralin	1.50	10-14	Disk harrow 4 inches deep	a. Glyphosate (Roundup 4E)	1.00	7-6	RCS[2]	JG	30-40"
B. Profluralin	1.50	10-14	Disk harrow 4 inches deep	b. Bentazon	0.75	6-12	OT	CB	4"
				Bentazon	0.75	6-28	OT	CB	4"
				Glyphosate	1.50	7-6	RCS	JG	30-40"
C. Trifluralin	1.50	10-14	Disk harrow 4 inches deep	c. Naptalam + Dinoseb (Dyanap 3E)	2.25	5-29	OT	-	SB[5] cracking
				Bentazon	0.75	6-12	OT	CB	4"
				Bentazon	0.75	6-28	OT	CB	4"
				Glyphosate	1.50	7-6	RCS	JG	30-40"
D. Pendimethalin	1.50	10-14	Disk harrow 4 inches deep	d. Bentazon	0.75	6-12	OT	CB	4"
				Bentazon	0.75	6-28	OT	CB	4"
E. None (check)	--	--	---						
		Spring 1979				1979			
A. Fluchloralin	0.75	6-12	Power incorporator 2 inches deep	a. Glyphosate	1.50	7-25	RCS	JG	24-30"
B. Profluralin	0.75	6-12	Power incorporator 2 inches deep	b. Bentazon	0.75	7-2	OT	CB	1-5"
				Glyphosate	1.50	7-25	RCS	JG	24-30"
C. Trifluralin	0.75	6-12	Power incorporator 2 inches deep	c. Naptalam + Dinoseb	4.50	6-18	OT	-	SB cracking
				Bentazon	0.75	7-2	OT	CB	1-5"
				Glyphosate	1.50	7-25	RCS	JG	24-30"
D. Pendimethalin	0.75	6-12	Power incorporator 2 inches deep	d. Bentazon	0.75	7-2	OT	CB	1-5"
E. None (check)	--	--	---						

[1] over-the-top

[2] recirculating sprayer

[3] johnsongrass

[4] cocklebur

[5] soybeans

each year. Recommended seedbed preparation, fertilization and other production practices were used. Row middles were clean cultivated.

Weeds on a preselected row on the main plot that was not treated preplant with herbicides (check) were counted three weeks after planting each year (Table 2). Injury to soybeans by the herbicides was determined by .inspection, and effectiveness of the herbicides for control of weeds was rated on a scale of 0 = no control to 100 = complete kill. Mid-season evaluations of weed control were made in June or early July, and late-season ratings were made in September.

Johnsongrass plants on a 1-ft by 3-ft area selected randomly from an inside row of each subplot were counted on June 4, 1980 to determine the long-term benefits of repeated use of the herbicide programs used in the trial.

The two center rows of each subplot were combine harvested for yield determination.

Results

Seedling johnsongrass and cocklebur were the most numerous weeds on the untreated control three weeks after planting in 1977, but seedling johnsongrass plants far outnumbered other weed species three weeks after the control was planted in 1978 and 1979 (Table 2). Occasional large crabgrass and redroot pigweed plants also were observed each year.

Johnsongrass control

Mid-season johnsongrass control of the main plots did not differ by treatment ($P < .05$) in 1977 and 1978, and late-season control did not differ by treatment in 1977. Mid-season control in 1979 was significantly better with all preplant herbicides than for the untreated check, and fluchloralin was better than pendimethalin. Late-season control in 1978 did not differ by herbicide treatment, but pendimethalin was not better than the check. Johnsongrass control in late-season in 1979 was better with fluchhloralin, profluralin and trifluralin than with pendimethalin, and pendimethalin was no better than the check. The three-year average mid-season and late-season johnsongrass control did not differ by herbicide treatment, but pendimethalin was not better than the check.

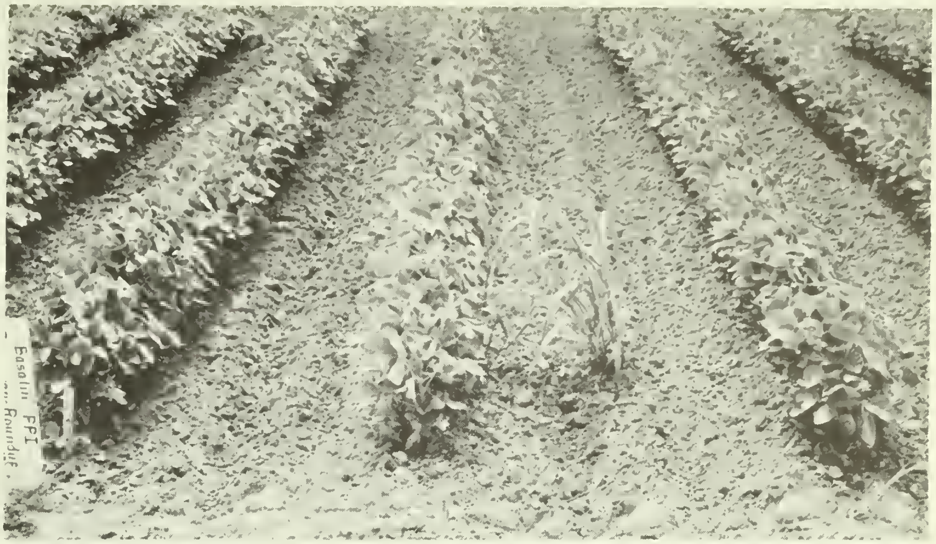

Figure 3. BASALIN (same as in 1 above). BASAGRAN (same as in 2 above). ROUNDUP (same as in 1 above). Shows excellent control of both Johnsongrass and Cocklebur.
Picture - July 17, 1979.

Table 2. Weeds per square foot of row on main plots that were not treated with preplant herbicides in trials at the MAFES North Mississippi Branch, by weed species and year, 1977-79.

Weed species	Year 1977	 1978	 1979
	Number		
Seedling johnsongrass	4.0	11.8	6.7
Rhizome johnsongrass	1/	1.4	0.9
Common cocklebur	4.1	2.3	1.9
Annual morningglory 2/	1.5	0.7	2.1

1/ Not determined.

2/ Entireleaf 50% and pitted 50%.

Soybeans were not injured by any preplant herbicide in any year, and the 1977, 1979 and three-year average yields did not differ by main-plot treatment. Yields did not differ by herbicide treatment in 1978 (a very dry year), but yields from fluchloralin- and pendimethalin-treated plots were no better than the check.

Control of common cocklebur was not affected by any preplant herbicide in any year. Postplant applications of bentazon gave such excellent control of common cocklebur that this plant did not compete with soybeans. Naptalam + dinoseb (2.25 lbs ai/acre) applied to soybeans at cracking in 1978 gave poor cocklebur control. Excellent cocklebur control was obtained with naptalam + dinoseb applied at 4.5 lb ai/acre in 1979, but a later application of bentazon was necessary because of newly germinated weeds. Yields in 1979 were highest following postplant treatment with naptalam + dinoseb followed by two applications of bentazon and one application of glyphosate, but not significantly higher than when two applications of bentazon were followed by one application of glyphosate (Table 3

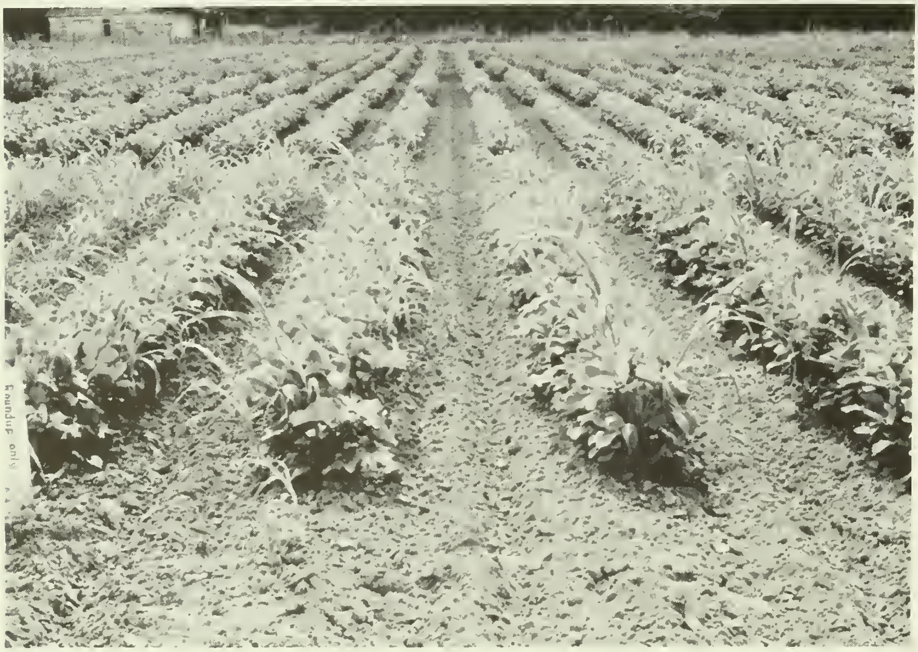

Figure 4. ROUNDUP (same as in 1 above). Shows fair control of Johnsongrass and no control of Cocklebur.
Picture - July 17, 1979.

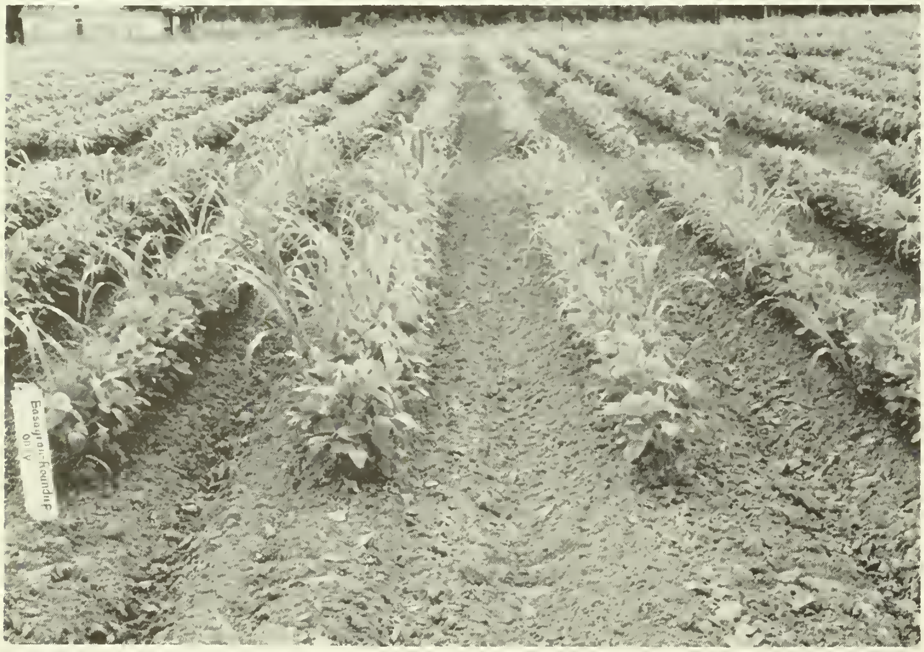

Figure 5. BASAGRAN (same as in 2 above). ROUNDUP (same as in 1 above). Shows fair control of Johnsongrass and excellent control of Cocklebur.
Picture - July 17, 1979

Mid-season control of johnsongrass with postplant herbicides was best in two of the three years with metriflufen followed by glyphosate but differed significantly (P < .05) from Treatment c (Table 3) only in 1979. Late-season johnsongrass control was best each year with metriflufen followed by glyphosate but did not differ (P >.05) from Treatment c in 1977 and 1978 and Treatment b in 1979.

The effectiveness of postplant herbicides for control of johnsongrass and cocklebur was reflected in soybean yields each year (Table 3). Yields were highest when johnsongrass and cocklebur both were controlled (Treatments and c).

Counts of rhizome johnsongrass plants after application of each preplant herbicide to the same plot for three years were lowest for fluchloralin and profluralin (Table 4). Rhizome johnsongrass counts after three years were lowest for postplant Treatments a and b but were not significantly lower than for Treatment c.

Our results indicate that a johnsongrass population of 52,200 to 154,200 plants/acre and a common cocklebur population of 24,800 to 53,500 plants/acre are about equally competitive with soybeans and that realization of maximum soybean yields requires a program for control of all weeds that are expected to be a problem in a soybean field. Additional benefits can be expected to accrue from repeated use of effective herbicide programs for control of johnsongrass when soybeans are grown in continuous rotation in fields with heavy infestations of johnsongrass.

Table 3. Johnsongrass control and soybean yield after application of preplant and postplant herbicides, MAFES North Mississippi Branch, 1977-79.

	Johnsongrass control[1]								Yield			
	Mid-Season				Late-Season							
Main plot preplant treatments[2]	1977	1978	1979	$\bar{X}$	1977	1978	1979	$\bar{X}$	1977	1978	1979	$\bar{X}$
	% Johnsongrass control								bu/acre			
A. Fluchloralin	76 a	79 a	91 a	82 a	66 a	76 a	90 a	80 a	16.3 a	11.8 ab	34.6 a	20.9 a
B. Profluralin	74 a	88 a	84 ab	83 a	72 a	86 a	89 a	83 a	16.8 a	13.9 a	35.0 a	21.9 a
C. Trifluralin	69 a	73 a	82 ab	75 a	59 a	69 a	90 a	77 a	18.4 a	14.5 a	35.1 a	22.7 a
D. Pendimethalin	60 a	67 a	64 b	63 ab	58 a	61 ab	77 b	68 ab	14.5 a	11.5 ab	35.6 a	20.5 a
E. None	63 a	57 a	13 c	34 b	51 a	25 b	65 b	47 b	16.6 a	9.5 b	28.8 a	18.3 a
Subplot postplant treatments[3]												
	% Johnsongrass control								bu/acre			
a. Metriflufen + surfactant, 1977; glyphosate, 1978 and 1979	94 a	85 a	90 a	87 a	90 a	79 a	94 a	89 a	14.0 b	9.7 b	29.4 c	17.7 b
b. Bentazon, chlordimedon, bentazon, 1977; bentazon, bentazon, glyphosate, 1978; bentazon, glyphosate, 1979	73 b	67 b	72 b	69 c	54 b	61 b	93 a	76 b	18.2 a	13.6 a	35.9 a	22.6 a
c. Bentazon, metriflufen + surfactant, bentazon, 1977; naptalam + dinoseb, bentazon, bentazon, glyphosate, 1978; naptalam + dinoseb, bentazon, glyphosate, 1979	90 a	87 a	74 b	78 b	85 a	73 a	87 b	81 b	19.5 a	15.2 a	37.3 a	24.0 a
d. Bentazon, bentazon, 1977 and 1978; bentazon, 1979	18 c	50 c	36 c	34 d	17 c	45 c	44 c	30 c	14.4 b	10.3 b	32.7 b	19.1 b

1/ Determined visually: 100% = complete kill.

2/ Results are averages of the four postplant treatments applied to each preplant treatment each year. Means with the same letter in a column do not differ ($P < .05$) according to DMRT.

3/ Results are averages of the four preplant treatments after each postplant treatment each year. Means with the same letter in a column do not differ ($P < .05$) according to DMRT.

Table 4. Johnsongrass infestation after three years of trials for control of johnsongrass and common cocklebur in soybeans, by herbicide treatments MAFES, North Mississippi Branch.

Main plot preplant treatments[1]	Rhizome johnsongrass[2]
	No. plants/row ft
A. Fluchloralin	0.18 b
B. Profluralin	0.15 b
C. Trifluralin	0.57 ab
D. Pendimethalin	0.40 ab
E. None (Check)	0.80 a
Subplot postplant treatments	
a. Metriflufen + surfactant, 1977; glyphosate, 1978 and 1979	0.25 b
b. Bentazon, chlordimedon, bentazon, 1977; bentazon, bentazon, glyphosate, 1978; bentazon, glyphosate, 1979	0.28 b
c. Bentazon, metriflufen + surfactant, bentazon, 1977; naptalam + dinoseb, bentazon, bentazon, glyphosate, 1978; naptalam + dinoseb, bentazon, glyphosate, 1979	0.34 b
d. Bentazon, bentazon, 1977 and 1978; bentazon, 1979	0.81 a

1/ Means in a treatment group followed by the same letter do not differ (P .05) according to DMRT.

2/ Based on three counts made June 4, 1980 from a 1-ft by 3-ft area centered on an inside row of each subplot.

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Bulletin 907

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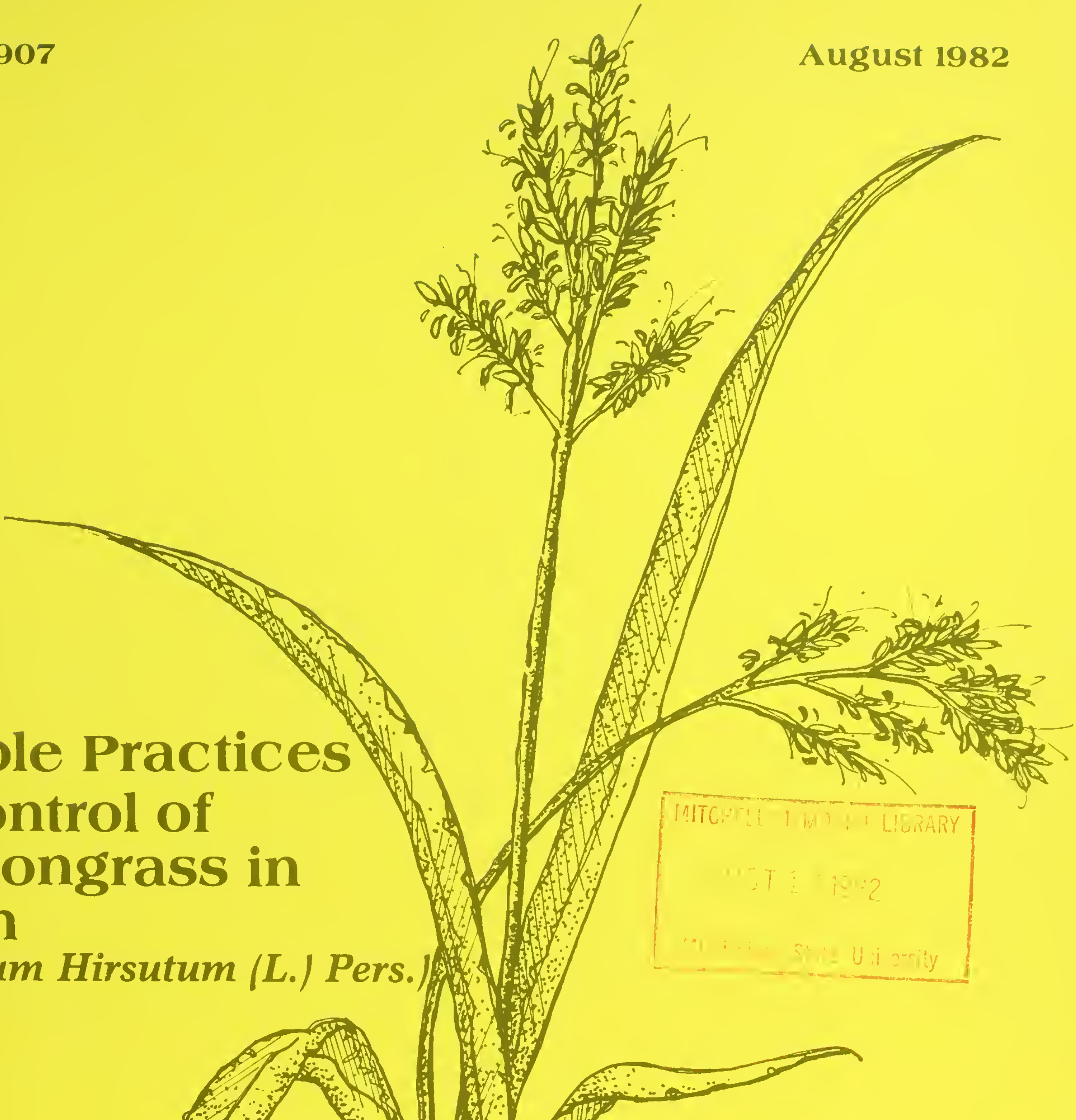

Multiple Practices for Control of Johnsongrass in Cotton

(Gossypium Hirsutum (L.) Pers.)

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(Gossypium Hirsutum (L.) Pers.)

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(Gossypium Hirsutum (L.) Pers.)

It has been estimated that cotton farmers in Mississippi lost more than $81 million to weeds in 1978 (4). Each weed species usually requires a different control strategy, and many chemicals and/or mechanical techniques are used for control of problem weeds in cotton.

Houston (1979) listed johnsongrass [*Sorghum halepense (L.) Pers*] as the fifth most common weed and the second most troublesome weed in cotton in 1978 (3), and the species is especially difficult to control in cotton. Studies have shown that dinitroaniline herbicides (e.g., trifluralin) control johnsongrass very effectively (2,5). Glyphosate also has controlled johnsongrass very effectively (1,6).

We report in this publication the results of a study of the effectiveness of herbicides for control of johnsongrass in cotton.

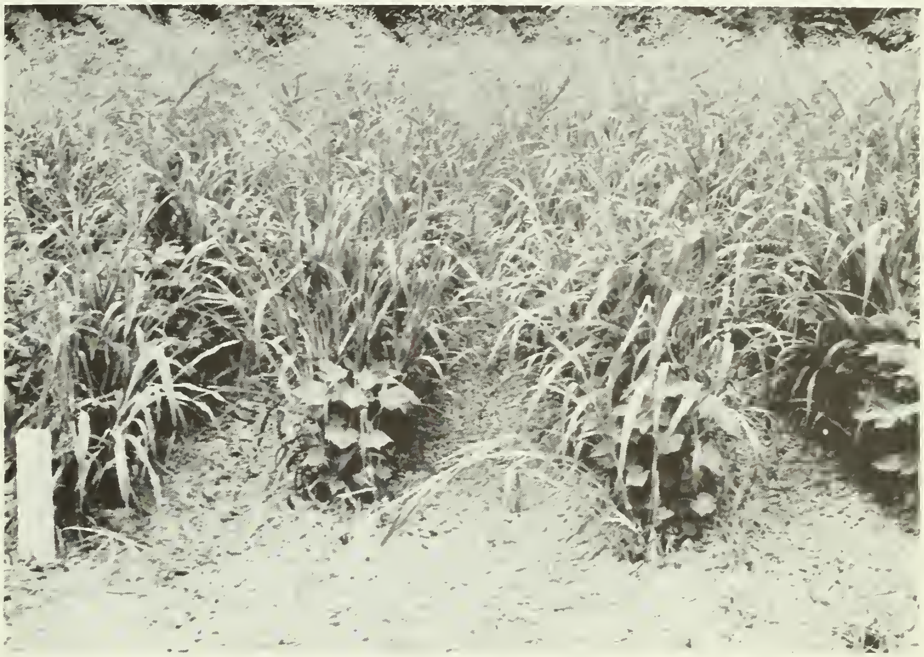

Figure 1. No Herbicide, only cultivation (for 3 years).

Picture — July 17, 1979.

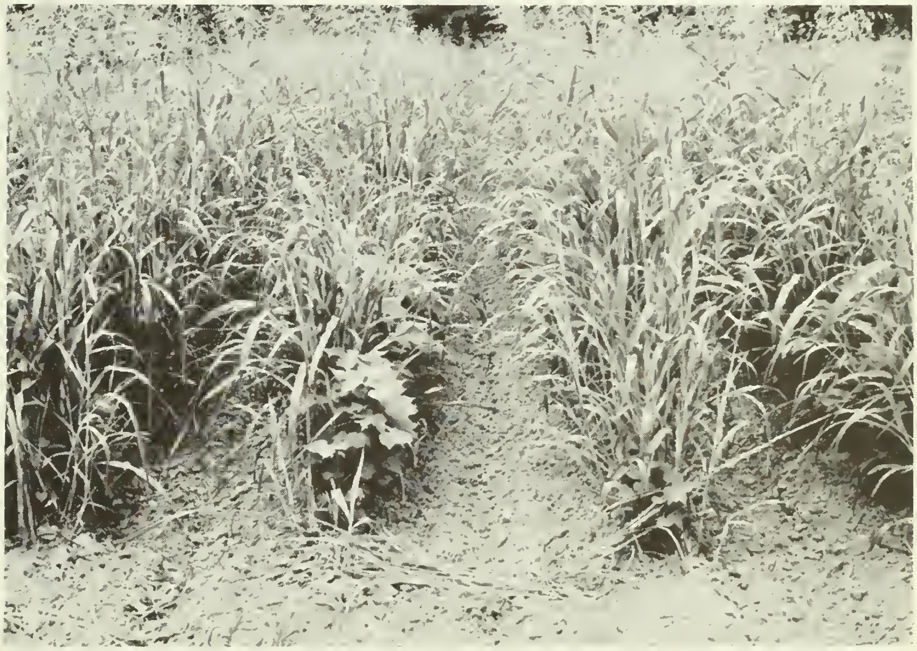

Figure 2. MSMA 0.7 Over-the-Top + cultivation. MSMA applied OT 2" cotton 5/27/77+ repeat 6/2 OT 2" cotton 5/29/78. OT 6" cotton 6/5/79.

Picture — July 17, 1979.

Materials and Methods

The three-year trial was conducted at the MAFES North Mississippi Branch on a silt loam (19.6% sand, 66.8% silt, 13.6% clay) with 1.2% organic matter and pH of 5.9. The design was a split plot with four replications.

Main plots were 16 rows (40 inches wide and 30 ft long), and treatments were a check (no herbicide) and preplant application of trifluralin, dinitramine/profluralin, butralin or Dowco 295® in 1976, 1977, 1978 and 1979 (Table 1). Fall-applied herbicides were incorporated 3-4 inches deep by two passes with a four-row tandem disk

Table 1. Design of trial for johnsongrass control in cotton, MAFES North Mississippi Branch, 1977-1979.

Main Plot Preplant Treatments[1]					Treatments Superimposed on Each Main Plot Treatment[2]					
		Lbs ai/	Broadcast and incorporated				Lbs/ai	Application		
No.	Herbicides	acre	Date	Method	No.	Herbicides	acre	Date	Method	Stage
		Fall 1976, Spring 1977						1977		
I	Trifluralin (Treflan 4E)	1.50	10-22-76	Tandem disk twice with 2nd pass at 45° angle to first	1	Fluridone (EL 171 4AS)	0.60	5- 9-77	Incorporated 2 inches deep on bed with power incorporator	Preplant
II	Dinitramine (Cobex 2E)	1.00	10-22-76	Tandem disk twice with 2nd pass at 45° angle to first	2	Metriflufen + surfactant (HOE 29152 3E)	1.50	6- 1-77	Post - Directed	4-inch cotton
	Profluralin (Tolban 4E)	1.50	4-20-77	Tandem disk twice with 2nd pass at 45° angle to first		MSMA (Hi-Yield 4E)	1.00	6- 2-77	Over-the-top	4-inch cotton
III	Butralin (Amex 4E)	3.00	10-22-76	Tandem disk twice with 2nd pass at 45° angle to first	3	MSMA MSMA	0.70 0.70	5-27-77 6- 2-77	Over-the-top Over-the-top	2-inch cotton 4-inch cotton
IV	None	---	---	---	4	None	---	---	---	---
		Fall 1977, Spring 1978						1978		
I	Trifluralin	1.50	10-14-77	Tandem disk twice with 2nd pass at 45° angle to first	1	Fluridone	0.60	5-18-78	Incorporated 2 inches deep on bed with power incorporator	Preplant
II	Profluralin	1.50	10-14-77	Tandem disk twice with 2nd pass at 45° angle to first	2	MBR 18337 2S MBR 18337	0.50 0.50	6-10-78 7-13-78	Over-the-top Over-the-top	6-inch johnsongrass 20-inch johnsongrass
III	Dowco 295 6E	3.00	5-18-78	Incorporated 2 inches deep after bedding with power incorporator	3	MSMA (Bueno 6E)	0.70	5-29-78	Over-the-top	2-inch cotton
IV	None	---	---	---	4	None	---	---	---	---
		Spring, 1979						1979		
I	Trifluralin	0.75	5-18-79	Incorporated 2 inches deep after bedding with power incorporator	1	Fluridone	0.60	5-18-79	Incorporated 2 inches deep on bed with power incorporator	Preplant
II	Profluralin	0.75	5-18-79	Incorporated 2 inches deep after bedding with power incorporator	2	MBR 18337 MBR 18337	0.50 0.50	6- 5-79 7- 6-79	Over-the-top Over-the-top	12-inch johnsongrass 24-inch johnsongrass
III	Dowco 295	3.00	5-18-79	Incorporated 2 inches deep after bedding with power incorporator	3	MSMA	0.70	6- 5-79	Over-the-top	6-inch cotton
IV	None	---	---	---	4	None	---	---	---	---

[1] Dinitramine was used in 1976 but its availability was lost so profluralin was used in the spring and fall of 1977 and spring of 1979. Likewise, butralin was used in the fall of 1976 and its availability was also lost so Dowco 295 was used as a spring treatment after bedding in 1978 and 1979.

[2] Fluometuron (Cotoran 4L or 80W) was applied preemergence at 1.25 lb ai/A each year to treatments 2,3, and 4; all row middles were clean cultivated.

harrow, with the second pass at a 45° angle to the first. Spring applied herbicides were incorporated 2 inches deep with a power incorporater after bedding.

Herbicide treatments were superimposed on four rows of each herbicide-treated main plot in spring 1977, 1978 and 1979 (Table 1). The spring treatments were single or sequential applications of herbicides preplant incorporated on the bed, postdirected or over-the-top, and fluometuron (1.25 lbs ai/acre) was applied for broadleaf control except where fluridone was superimposed preplant incorporated.

The repeated treatments were applied to the same plots each year. All treatments were applied broadcast in 20 gal spray volume per acre.

'Stoneville 213' or 'Stoneville 731 N' seed were planted on or about May 10, 1977, 1978 and 1979. Recommended fertilization, planting and insecticide control practices were followed, and two o three cultivations were used t control weeds in the row middles.

Weeds on three 1 sq ft-areas of preselected row of the untreate control were counted by specie about three weeks after plantin each year. Evaluations of wee control were made in June, Jul and September each year.

Yield determinations were base on once-over harvest from the tw center rows of each superimpose plot.

Results

Weed counts in the untreated ontrol three weeks after planting ere highest for seedling johnongrass each year (Table 2). hizome johnsongrass was not resent in 1977 but had increased o 6.5 plants/3 sq ft by 1979.

The interaction between main lot and superimposed treatments n 1977 was not significant. Johnongrass control was better and eed cotton yield was higher with rifluralin and dinitramine/ rofluralin applied preplant than or the untreated check and buralin applied preplant (Table 3). Superimposed treatment with metriflufen - MSMA gave significantly better johnsongrass control than resulted from other superimposed treatments when rated in June and July but was not significantly more effective than fluridone when rated in September.

The interaction between main plot and superimposed treatments was significant in 1978 and 1979. Johnsongrass control (September 1977 rating) with fluridone (73%) and metriflufen (81%) applied without preplant treatments (Table 3) did not extend into 1978 (Table 4) when control with fluridone and metriflufen (MBR18337) without preplant treatments (June 1978 rating) was 48 and 35%, respectively. Control of johnsongrass at each evaluation date in 1978 generally was best when MBR 18337 was superimposed on the preplant herbicides (Table 4); however, this advantage in johnsongrass control was not associated with significantly higher yields (Table 5).

The best control of johnsongrass with fluridone in 1978 was when it was superimposed on the profluralin treatment. MSMA superimposed on trifluralin gave better johnsongrass control (September 1978 rating) than was obtained with MSMA superimposed on the other preplant herbicides, and yields from plots with

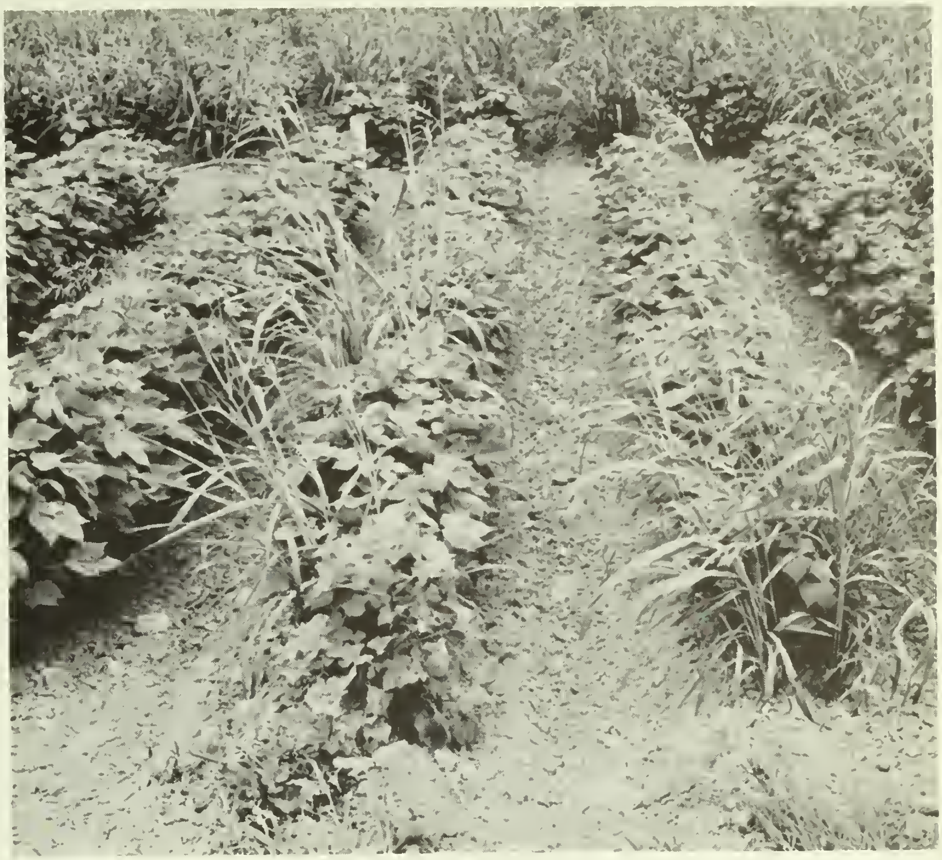

Figure 3. Treflan 1.5 LB/A in fall 1976, 1977 (Disk incorporated) + 0.75 in spring 1979 (Power driven incorporated).

Picture — July 17, 1979.

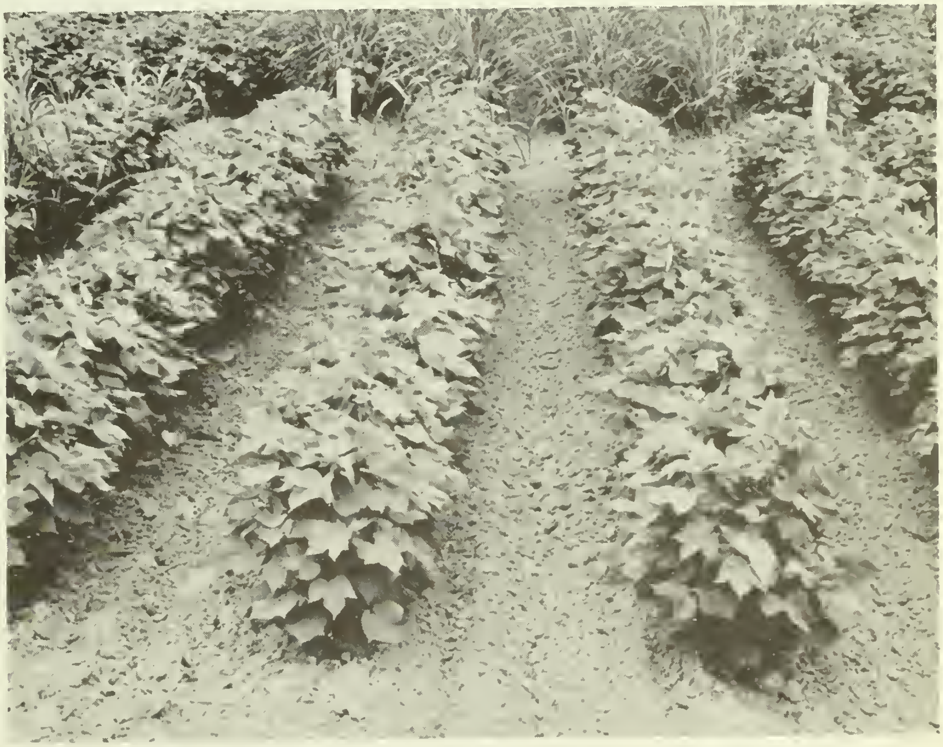

Figure 4. Treflan (same as in 3 above). MSMA (same as in 2 above). Picture — July 17, 1979.

MSMA superimposed on trifluralin were the highest in the 1978 trial.

Control of johnsongrass at each evaluation date in 1979 generally was best when MBR 18337 was superimposed on the preplant herbicides (Table 6), and this advantage in johnsongrass control was associated with higher yields ($P < .05$) in two main plot/superimposed treatments (Table 7). MSMA superimposed on trifluralin or profluralin gave better johnsongrass control (September 1979 rating) than was obtained with MSMA superimposed on butralin, and yields from the MSMA/trifluralin and MSMA/profluralin plots in 1979 were as high as yields from the MBR 18337/trifluralin and MBR 18337/profluralin plots.

Conclusions

The 1979 results of this study suggest that two applications of MBR 18337 to the same plots in the previous two years eliminated the need for preplant herbicides. The excellent control of johnsongrass with MBR 18337 indicated its extended effectiveness, and this was reflected in the high yield from this treatment in 1979. Early-season, over-the-top applications of MSMA did not delay maturity or reduce yield of cotton; however, MSMA required the use of effective preplant herbicides for more effective johnsongrass control and higher cotton yields.

Results of our study reinforce the results of other studies with registered preplant, soil-incorporated herbicides for control of johnsongrass in cotton. The results also indicate a potential advantage for early-season use of over-the-top herbicides now being developed to augment or replace the preplant, soil-incorporated herbicides now used in a continuous cotton rotation.

Table 2. Weeds in the untreated control in a study of the effectiveness of herbicides for control of johnsongrass in cotton, MAFES North Mississippi Branch, 1977-79.[1/]

Species	Year 1977	 1978	 1979
	------------	No/3 sq. ft.	------------
Seedling johnsongrass	8.3	52.5	48.0
Rhizome johnsongrass	3/	4.8	6.5
Large crabgrass	2.8	3/	0.5
Goosegrass	0.8	3/	3/
Annual morningglory[2/]	0.8	1.0	0.3
Common cocklebur	4.5	4.5	1.0
Redroot pigweed	0.5	3/	0.8

1/ Values are an average of three 1-sq. ft. areas of a preselected row.

2/ Equal numbers of ivyleaf, entireleaf, and pitted.

3/ Not present.

Table 3. Effect of main plot preplant herbicide treatments and superimposed herbicide treatments on johnsongrass control and seed cotton yield, by treatment, MAFES North Mississippi Branch, 1977.[1/]

Item	Johnsongrass control when rated in June	 July	 September	Seed cotton yield
	------------	%	------------	lbs/acre
Main Plot Preplant Treatments[2/]				
I. Trifluralin	92 a	68 a	64 a	1124 a
II. Dinitramine-Profluralin	83 a	79 a	79 a	1209 a
III. Butralin	56 b	34 b	35 b	774 b
IV. None	46 b	33 b	42 b	696 b
Superimposed Treatments[2/]				
1. Fluridone	70 b	50 b	73 a	1149 a
2. Metriflufen-MSMA	92 a	85 a	81 a	1171 a
3. MSMA	59 b	43 b	34 b	739 b
4. None	56 b	36 b	32 b	745 b

1/ Johnsongrass control was visually determined (0 = no injury, 100 = complete kill).

2/ Means in a column followed by the same letter are not different ($P < .05$) according to DMRT.

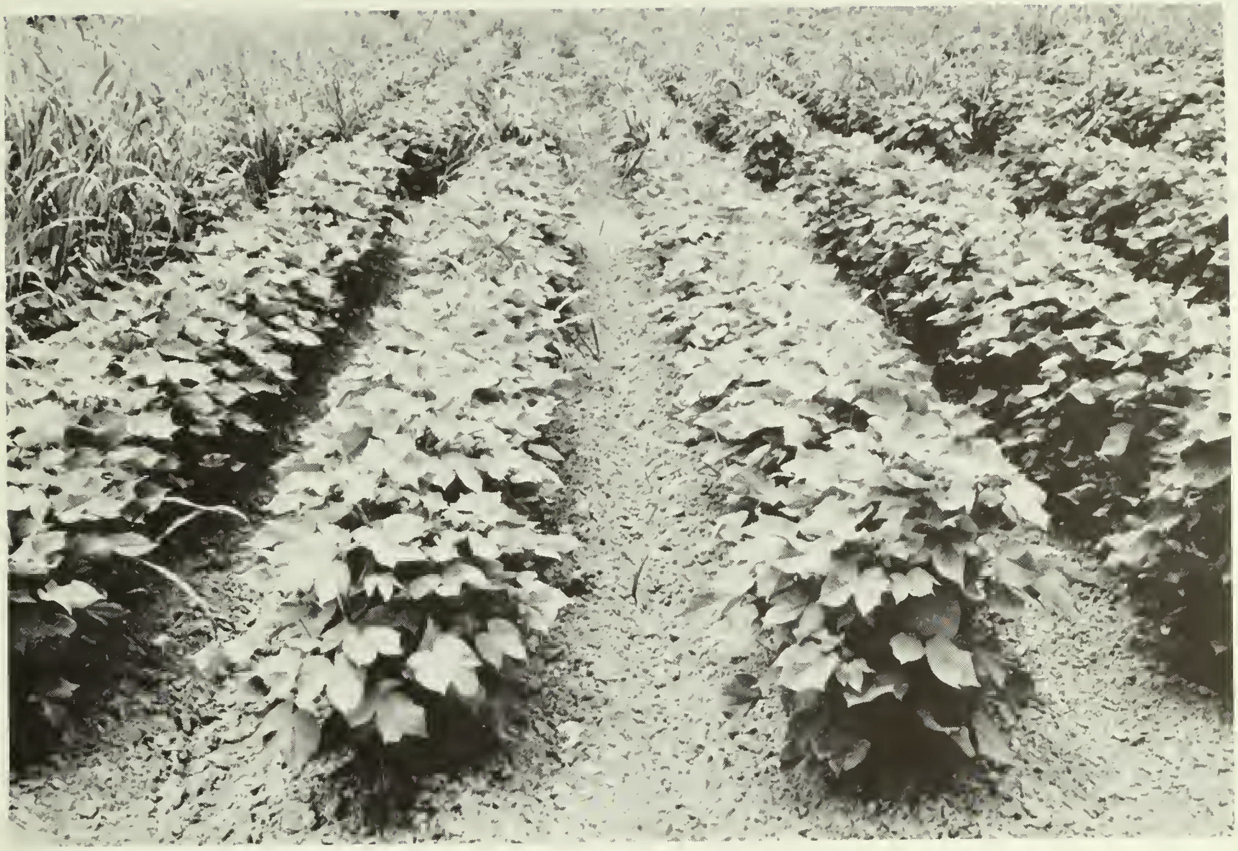

Figure 5. MBR 18337 0.5 LB/A Over-the-Top 6″ JG 6-10-78 + repeat 7/13 and 12″ JG 6/5/79 + repeat 7/6 Picture — July 17, 1979.

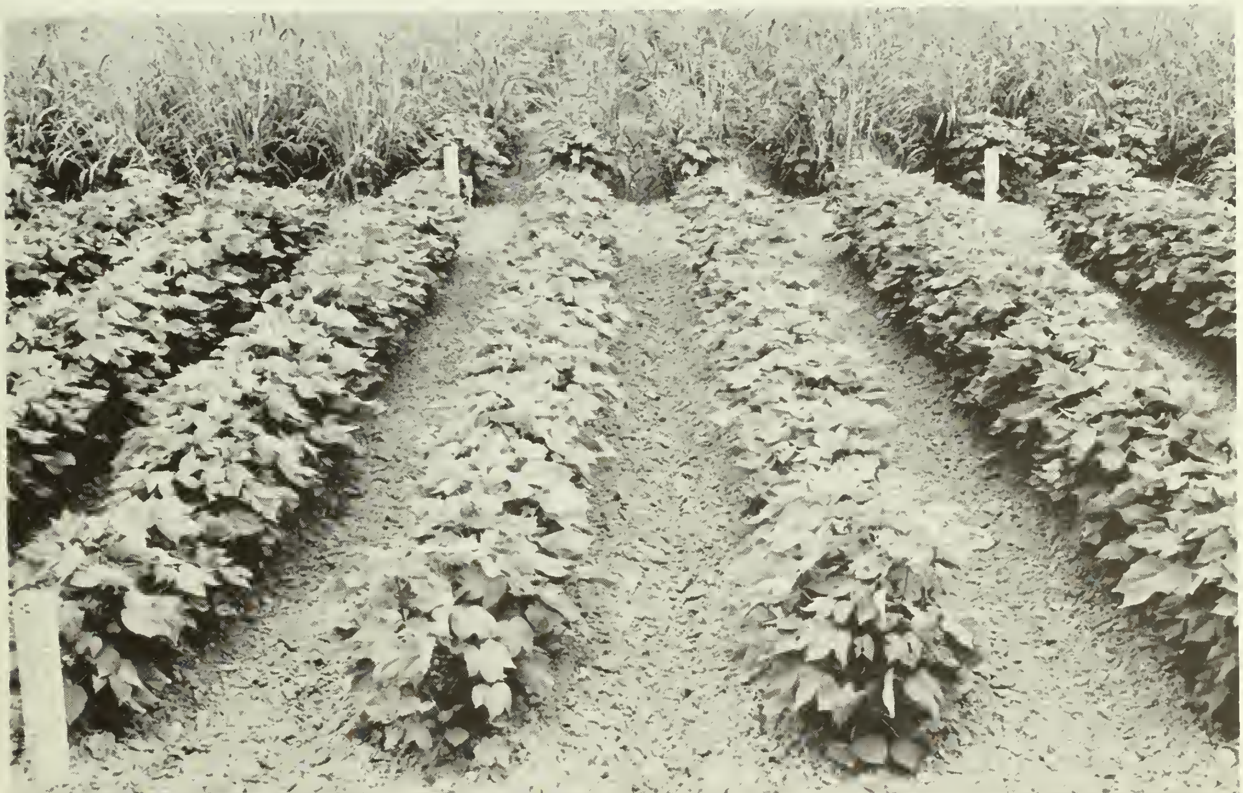

Figure 6. Treflan (same as in 3 above). MBR 18337 (same as in 5 above). Picture — July 17, 1979.

Table 4. Interaction effects of main plot preplant herbicide treatments and superimposed herbicide treatments on johnsongrass control in cotton, by treatment and dates johnsongrass ratings were made, MAFES North Mississippi Branch, 1978.

Main plot preplant treatments	Superimposed treatments: 1. Fluridone	2. MBR 18337	3. MSMA	4. None	Average
	% Johnsongrass Control				
	June Rating				
I. Trifluralin	65 bB[1]	95 aA	93 aAB	88 aAB	85
II. Profluralin	89 aA	95 aA	91 aA	58 bB	83
III. Butralin/DOWCO 295	68 bA	86 aA	68 bA	3 cB	56
IV. None	48 bA	35 bAB	38 cAB	3 cB	31
Average	68	78	73	38	
	July Rating				
I. Trifluralin	43 bB[1]	94 aA	91 aA	68 aAB	74
II. Profluralin	83 aA	89 aA	88 aA	28 bB	72
III. Butralin/DOWCO 295	43 bB	83 aA	58 bAB	6 bC	48
IV. None	34 bAB	61 bA	35 bAB	5 bB	34
Average	51	82	68	27	
	September Rating				
I. Trifluralin	51 bC[1]	96 aA	91 aAB	66 aBC	76
II. Profluralin	76 aAB	91 aA	64 bB	6 bC	59
III. Butralin/DOWCO 295	48 bB	89 aA	28 cBC	0 bC	41
IV. None	15 cAB	53 bA	3 cB	0 bB	18
Average	48	82	47	18	

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[1] Means with the same lower case letter in a column or with the same upper case letter in a row are not different (P < .05) according to DMRT. Johnsongrass rating was determined visually (0 = no control, 100 = complete kill).

Table 5. Interaction effects of main plot preplant herbicide treatments and superimposed herbicide treatments on seed cotton yield, by treatment, MAFES North Mississippi Branch, 1978.

Main plot preplant treatments	Seed cotton yield, Superimposed treatments: 1. Fluridone	2. MBR 18337	3. MSMA	4. None	Average
	lbs/acre				
I. Trifluralin	626 abB[2]	893 aB	1350 aA	899 aB	942
II. Profluralin	1040 aA	899 aA	1144 aA	278 bB	840
III. Butralin/DOWCO 295	806 abA	986 aA	681 bA	131 bB	651
IV. None	463 aAB	697 aA	474 bAB	158 bB	448
Average	734	869	912	367	

---

[1] Yields generally were below average because of extensive drought during mid- and late-season.

[2] Means with the same lower case letter in a column or with the same upper case letter in a row are not different (P < .05) according to DMRT.

Table 6. Interaction effects of main plot preplant herbicide treatments and superimposed herbicide treatments on johnsongrass control in cotton, by treatment and dates johnsongrass ratings were made, MAFES North Mississippi Branch, 1979.

Main plot preplant treatments	Superimposed treatments				
	1. Fluridone	2. MBR 18337	3. MSMA	4. None	Average
	% Johnsongrass Control				
	June Rating				
I. Trifluralin	50 bC[1]	98 aA	83 aAB	66 aBC	74
II. Profluralin	73 aA	86 aA	70 aA	15 bB	61
III. Butralin/DOWCO 295	75 aA	88 aA	76 aA	15 bB	64
IV. None	10 bB	55 bA	0 bB	16 bB	
Average	52	82	57	24	20
	July Rating				
I. Trifluralin	46 aC[1]	99 aA	84 aB	68 aBC	74
II. Profluralin	55 aBC	98 aA	65 abB	30 bC	62
III. Butralin/DOWCO 295	68 aAB	90 aA	50 bcBC	28 bC	59
IV. None	28 bB	85 aA	21 cB	1 bB	34
Average	49	96	55	32	
	September Rating				
I. Trifluralin	44 aC[1]	99 aA	89 aB	66 aBC	75
II. Profluralin	68 aBC	99 aA	73 abB	37 bC	69
III. Butralin/DOWCO 295	63 aB	90 aA	51 bBC	15 bC	55
IV. None	5 bB	99 aA	13 cB	0 bB	29
Average	45	97	57	30	

[1] Means with the same lower case letter in a column or with the same upper case letter in a row are not different ($P < .05$) according to DMRT. Johnsongrass control was determined whereby (0 = no control, 100 = complete kill).

Table 7. Interaction effects of main plot preplant herbicide treatments and superimposed herbicide treatments on seed cotton yield, by treatment, MAFES North Mississippi Branch, 1979.

Main plot preplant treatments	Seed cotton yield				
	Superimposed treatments				
	1. Fluridone	2. MBR 18337	3. MSMA	4. None	Average
	lbs/acre				
I. Trifluralin	1231 aA[1]	1481 aA	1497 aA	1481 aA	1423
II. Profluralin	1171 aBC	1710 aA	1470 aAB	768 bcC	1280
III. Butralin/DOWCO 295	1476 aB	1590 aAB	1220 aBC	861 bC	1287
IV. None	632 bB	1786 aA	653 bB	354 cB	856
Average	1128	1642	1210	866	

[1] Means with the same lower case letter in a column or with the same upper case letter in a row are not different ($P < .05$) according to DMRT.

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Bulletin 908

September 1982

Effects of Various Settings and Speeds of the Beehive Machine on the Composition of Mechanically Deboned Beef and Pork

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Effects of Various Settings and Speeds of the Beehive Machine on the Composition of Mechanically Deboned Beef and Pork[1]

Kantilal G. Bhojani[2], G. R. Ammerman[3], and R. W. Rogers[4]

Mechanical deboning is the only economical method for final removal of meat from bones, and the use of mechanical deboners can result in an additional annual production of over 700 million pounds of beef and over 300 million pounds of pork for human consumption, American Meat Institute (1975).

A mechanical deboning system was developed by the Japanese 25 years ago to remove meat from fish bones; this system has been used for deboning all types of raw and cooked meat, *Food Engineering* (1970). The poultry industry is using this system very successfully for deboning chicken necks and backs as well as turkey racks and spent laying hens, Noble (1973).

Grunden *et al.* (1972) reported that mechanically deboned meat produced different physical and chemical characteristics. The ash and calcium content of mechanically deboned meat was always higher than for hand-deboned meat because some fine bone particles were passed through the holes of the deboner, Field *et al.* (1974). Grunden and MacNeil (1973) reported that the bone content of mechanically deboned poultry meat can be determined by ethylenediaminetetraacetic acid or atomic absorption spectrophotometric methods; both give similar results. (Factors used for converting percent calcium to percent bone were 6.25 for broilers and 4.55 for mature poultry. A factor of 0.015 was allowed for calcium naturally occurring in meat.) Hand-boned lamb breast had a higher hydroxyproline content than machine-boned lamb breast because much of the connective tissue was eliminated by the mechanical deboner, Field (1974).

Field (1974) analyzed yields and the fat, protein, moisture, ash, and calcium content of mechanically deboned meat from trimmed pork necks andback bones; he obtained a yield of about 30 to 40% meat by weight from trimmed neck bones. The temperature of the deboned product increased approximately 10-15°C during grinding and deboning; it follows that any delay in processing could cause an increased growth of psychrotrophic and psychroduric organisms, Ostovar *et al.* (1971).

Field *et al.* (1974) stated that when the ring valve of the Beehive deboner was tightened to increase yields, the calcium content of the meats was increased, with an increase in bone content of over 1% at the maximum level. They stated that the following factors affect the amount of calcium in mechanically deboned meat: size of grinder plate; size of the holes in the deboner; amount of meat left on bones; whether the product was raw or cooked; and whether the product was deboned on the killing floor while warm or after chilling.

High calcium content in mechanically deboned meat may not be harmful; it may help to prevent calcium deficiencies when the calcium content of meat is low, Watt and Merrill (1963) and the human diet is low in calcium, Walker (1972) and Lutwak (1974).

Field (1974) and over 40 meat companies did studies on mechanically deboned, partly trimmed, trimmed, and mixtures of partly trimmed beef and pork bones. The American Meat Institute (AMI) committee made the following conclusions and recommendations based on this work:

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[1] *Data taken from a master's thesis submitted in partial fulfillment of the requirements for a Master of Science degree at Mississippi State University.*

[2] *Graduate Assistant, Food Science Institute, MAFES (Mississippi Agricultural and Forestry Experiment Station).*

[3] *Professor of Food Technology, MAFES, P. O. Drawer T, Mississippi State, MS 39762.*

[4] *Professor of Animal Science, Animal Science Department, MAFES, Rm. 207, Ballew Hall, Mississippi State, MS 39762.*

1) The mechanically deboned meat should be considered a meat ingredient, not an end product. The calcium level should be controlled in the finished product. Mechanically deboned meat with a calcium content of 0.75% or under should be permitted in processed meat up to a maximum of 30% of the total product.
2) The mechanically deboned meat was equal or superior in quality to hand-deboned meat, so protein and fat restriction should be eliminated.

Table 1. Percent yield of mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

Setting	Meat	SPEED (RPM) 10	18	24	Average	Means for Settings
6K	Pork	18.25	15.50	15.25	16.33	20.10
	Beef	19.97	23.33	28.33	23.88	
7.5J	Pork	27.75	22.75	20.50	23.67	27.63
	Beef	30.50	31.34	32.92	31.59	
8.5H	Pork	27.75	28.25	26.00	27.33	38.60
	Beef	41.25	53.35	55.00	49.87	
Means for Speeds						
	Pork	24.58	22.17	20.58		
	Beef	30.57	36.01	38.75		

Overall yield: Beef 35.11%

Pork 22.44%

On November 6, 1974, the United States Department of Agriculture (USDA) approved the use of mechanically deboned red meat in meat products provided it met the following requirements, Meat Processors' Institute, (1974):

1) Content	*Beef %*	*Pork%*
(a) Minimum protein	15	14
(b) Maximum fat	30	30
(c) Maximum calcium	0.5	0.5
(d) Minimum essential amino acid	33	33

2) Maximum Temperature Limit:
(a) Ground raw products, 55°F
(b) Deboned products, 75°F
(c) Chilled products, 40°F or below

Approval was suspended in September, 1976, until further data could be obtained concerning safety for human consumption of products made from deboned meat. USDA has since deemed the use of deboned meat safe. It has proposed new regulations for manufacture and use of these products.

Little has been published on yield and composition of mechanically deboned beef and pork as related to back pressure setting and speed of the Beehive deboning machine. The objective of this research was to determine the effects of different deboner speeds and back pressure settings of the Beehive machine on yield and on calcium, fat, protein, moisture, and ash levels of mechanically deboned pork and beef.

Table 2. Percent calcium content of mechanically deboned beef and pork as affected by settings and speeds of Beehive deboner.

Setting	Meat	SPEED (RPM) 10	18	24	Average	Means for Settings
6K	Pork	0.152	0.192	0.208	0.184	0.376
	Beef	0.467	0.570	0.664	0.567	
7.5J	Pork	0.188	0.196	0.192	0.192	0.362
	Beef	0.505	0.594	0.498	0.532	
8.5H	Pork	0.168	0.204	0.200	0.191	0.435
	Beef	0.566	0.780	0.688	0.678	
Means for Speeds		0.341	0.423	0.408		

Overall average calcium: Beef 0.59%

Pork 0.19%

PROCEDURE

Three hundred pounds of mixed, mmed beef ribs, plates, and neck nes were obtained from a local cking company. These products ere machine deboned using a ehive Model AU-6173 deboner. bout 15% of the meat was left on e trimmed bones, to meet USDA quirements of not less than 15% otein and not more than 0.5% lcium, Meat Processors' Institute 974). The trimmed beef bones ere then passed through a bone inder equipped with plates havg 3/8-inch-diameter holes before mechanical deboning. Whole pork picnic bones were obtained from the same sources and treated in the same way.

Meat was forced through 0.018-inch-diameter holes in the Beehive cylinder while bones were eliminated through the cylinder end. This cylinder was used throughout the experiment at three speeds and three back pressure settings.

The mechanically deboned beef was mixed thoroughly before sampling. Protein, moisture, fat, ash, and calcium were measured by the Association of Official Agricultural Chemists methods, and duplicate values were determined for each sample, Horwitz (1970). Pork was mixed and measured in the same way.

The experimental design was a completely randomized 3 x 3 x 2 factorial experiment with three settings for back pressure, three machine speeds, and two kinds of meat. Each treatment was replicated twice.

RESULTS

elds

The yield of deboned products of ef and of pork differed gnificantly ($P < .01$). Yield for ef was higher than for pork---.11% compared to 22.4% (Table 1). Yields of both meats increased as ttings for back pressure ineased, with average percent of .10, 27.63, and 38.60 for Beehive achine settings of 6K, 7.5J, and 5H, respectively (Table 1). The fference in the yield between pork d beef was not the same at each tting (significant at $P < .01$). eans tested by Duncan's multiple nge test indicated that the pork eld increased when the setting as increased to 8.5H (Table 1).

A significant difference between e effect of speed on beef yield and pork yield was indicated. Means sted by Duncan's multiple range st showed the yield of beef was gnificantly higher ($P < .01$) when speed of 24 RPM was used instead f 10 RPM. Conversely, the pork nded towards a greater ($P < .05$) ield at the lower speed of 10 RPM; e differences for pork, however, ere not statistically significant.

alcium

The beef contained significantly ore ($P < .01$) calcium than the ork, 0.59% compared to 0.19% for ork (Table 2). There was no significant difference in the calcium content of deboned meat when the setting was increased from 6K to 7.5J, but there was a significant rise ($P < .05$) when the setting was increased from 7.5J to 8.5H.

The calcium content also rose ($P < 0.5$) when the speed of the machine was increased to 18 RPM (Table 2). The speed and setting showed no significantly different effects on either meat.

Protein

The beef contained significantly more protein than the pork---an average of 15.89% compared to 13.13% (Table 3). There was a highly significant effect ($P < .01$) on protein content due to the setting of the machine. The content rose when the machine setting was increased from 6K to 7.5J but showed no further rise when the setting was increased to 8.5H (Table 3).

Table 3. Percent protein in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	12.32	13.14	13.35	13.00	14.19
	Beef	15.00	15.38	15.76	15.38	
7.5J	Pork	13.46	13.46	13.68	13.53	14.93
	Beef	15.82	16.86	16.31	16.33	
8.5H	Pork	13.03	13.52	13.85	13.47	14.73
	Beef	15.93	15.82	16.20	15.98	
Means for Speeds		14.26	14.70	14.89		

Overall average protein: Beef 15.89%
Pork 13.13%

Speed significantly affected the protein content ($P < .05$). Meat ground at 24 RPM had a significantly ($P < .05$) higher percentage of protein than samples ground at 10 RPM. The protein content of meat ground at 18 RPM was not different from meat ground either at 10 RPM or at 24 RPM (Table 3). There was no significant differences between the two meats.

Fats

There was a significant difference in the fat content of the deboned product according to the type of meat. Pork was significantly higher ($P < .01$) in fat, with an average of 29.26%, compared to 18.16% for beef (Table 4).

Machine setting significantly affected fat content ($P < .05$). The 6K and 8.5H settings produced higher fat content ($P < .05$) for deboned meat than a setting of 7.5J (Table 4). There were no significant differences in fat content due to speed or between the two meats.

Ash

The beef was significantly higher in ash content than pork---on average 2.44% to 1.25% (Table 5). The ash content of beef increased at setting 8.5H ($P < .05$), but no difference was found in the pork at any setting (Table 5).

Moisture

There was a highly significant ($P < .01$) difference in the moisture content of deboned product between the two meats: beef had a significantly higher moisture content---averaging 63.17%, than pork, which averaged 55.80% (Table 6).

Moisture content was not significantly affected by setting or speed, and there were no differences between the two meats for these variables.

Table 4. Percent fat content in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means fo Settings
6K	Pork	33.43	29.95	30.20	31.19	25.42
	Beef	19.77	19.43	19.74	19.65	
7.5J	Pork	27.17	29.16	29.73	28.69	22.82
	Beef	19.42	16.45	14.94	16.94	
8.5H	Pork	30.22	28.60	28.52	29.11	24.19
	Beef	17.84	21.41	18.52	19.26	
Means for Speeds		24.64	24.17	23.61		

Overall average fat: Beef 18.16%

Pork 29.26%

Table 5. Percent ash content in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means fo Settings
6K	Pork	1.16	1.28	1.27	1.24	1.78
	Beef	2.03	2.29	2.62	2.31	
7.5J	Pork	1.28	1.29	1.23	1.27	1.78
	Beef	2.12	2.53	2.19	2.28	
8.5H	Pork	1.18	1.24	1.30	1.24	1.98
	Beef	2.50	3.09	2.57	2.72	
Means for Speeds		1.71	1.95	1.86		

Overall average ash: Beef 2.44%

Pork 1.25%

DISCUSSION

Removal of meat from beef bones was best achieved with a Beehive machine setting of 7.5J and a speed of 24 RPM; this resulted in a yield of 32.92%, an average calcium content of 0.498%, and an average fat content of 14.94%. These values are less than the USDA-approved levels, which were set to prohibit too much calcium in meat as the result of too much pulverized bo Meat Processors' Institute (197 The protein content of meat debo ed at the 7.5J setting and 24 RP was 16.31%, well above the USI minimum, Meat Processors' I stitute (1974).

The best machine back pressu

tting and speed for pork produc- on were 8.5H and 24 RPM, respec- vely. The yield for these settings as 26%, which was 4% lower than e value reported by Field (1974). e calcium content was 0.20%, otein 13.85%, and fat 28.52%. alcium and fat were below USDA- pproved values, as was the pro- in content.

SUMMARY

An evaluation was made of the fects of three settings of back ressure and three speeds of the eehive machine on yield of beef nd pork and on the calcium, rotein, fat, ash and moisture ontent of these meats. The verage yield of beef was 35.11% nd of pork, 22.44%.

Results indicated that the eehive machine should be set on .5J and operated at a speed of 24 PM for preparation of deboned eef with maximum protein content. The best setting and speed for preparation of deboned pork were 8.5H and 24 RPM, respectively. However, none of the settings or speeds tried resulted in meat with the minimum 14% protein presently recommended for pork obtained by mechanical deboning.

Table 6. Percent moisture content in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	53.39	55.60	55.41	54.80	58.69
	Beef	62.86	63.09	61.76	62.57	
7.5J	Pork	57.87	55.95	55.31	56.38	60.55
	Beef	62.69	64.42	67.06	64.72	
8.5H	Pork	55.63	56.52	56.52	56.22	59.22
	Beef	64.27	59.97	62.42	62.22	
Means for Speeds		59.45	59.26	59.75		

Overall average moisture for: Beef 63.17%

Pork 55.80%

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Bulletin 909

June 1982

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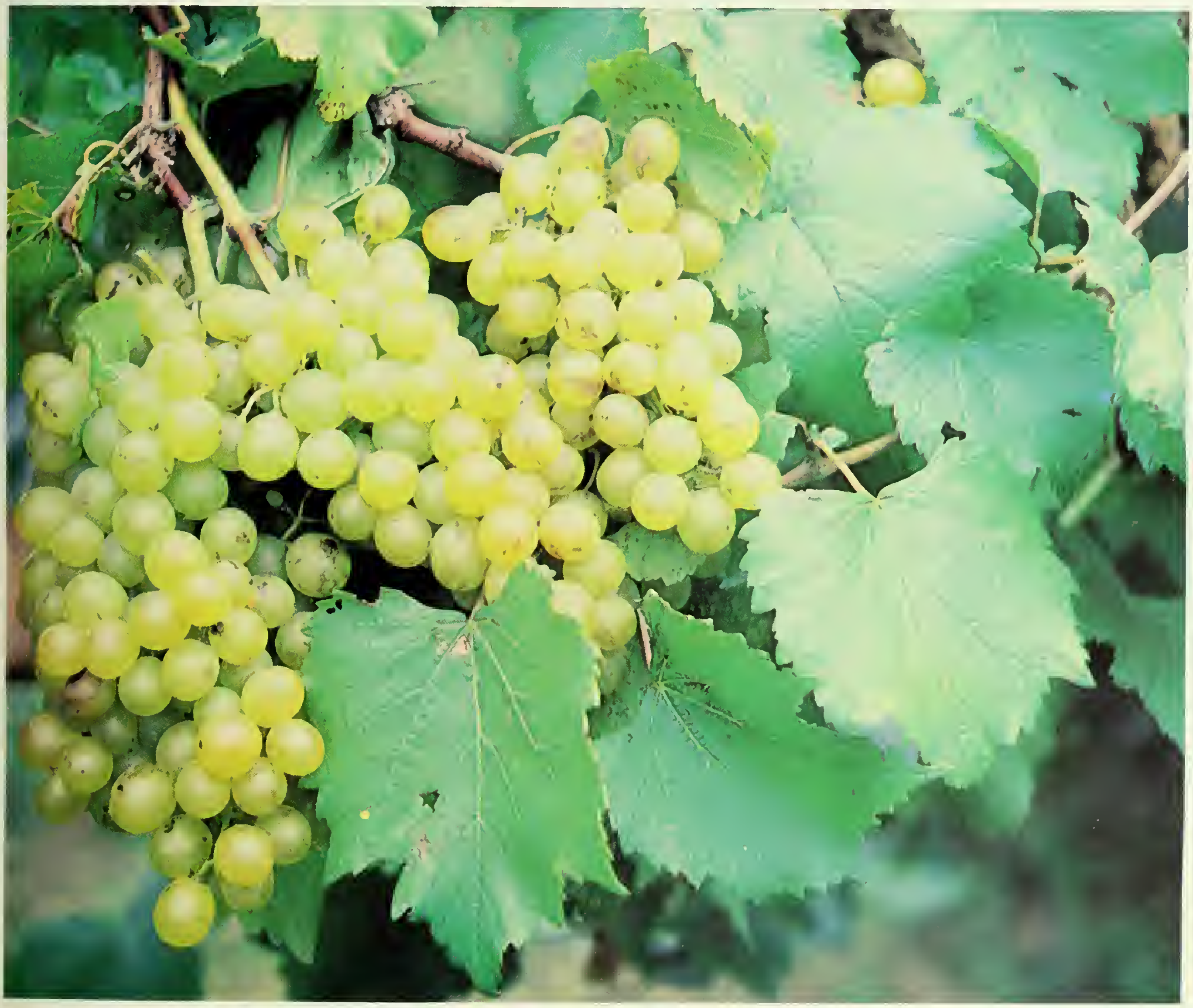
'Miss Blanc' A New Bunch Grape Cultivar



J.P. Overcash • C.P. Hegwood • B.J. Stojanovic

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Release Notice

The Plant Materials Release Committee of the Mississippi Agricultural and Forestry Experiment Station (MAFES) approved the release and naming of M26-4D as 'MissBlanc' in 1982. MissBlanc originated as a seedling from 'Extra', which had intraspecific parentage: *Vitis lincecumii* x *V. labrusca* x *V. vinifera* crossed with 'Marguerite' which had *V. lincecumii* x *V. bourquiniana* parentage.

'Miss Blanc'---A New Bunch Grape Cultivar for Mississippi

N. H. Loomis was a grape breeder at the USDA Horticultural Field Station at Meridian, Mississippi from 1934 to 1965. In addition to his breeding program, he tested many cultivars and root stocks for production and longevity and reported yields that ranged from 0 to 28 pounds per vine. Short vine life was an acute problem, with vines of many cultivars surviving only one to 12 years. Loomis primarily tested bunch grapes from the northeastern United States. Among these were 'Brocton', 'Concord', 'Delaware', 'Moore Early', 'Niagara', 'Portland' and at least 19 French-American hybrids. None of the latter lasted more than five years in the vineyard.

Pierce's disease is a bacterial complex of grapevines and has been estimated to have killed more than 80,000 acres of producing grapevines in southern California between 1880 and 1940 (1,2,3). Loomis and Overcash (4) cooperated with a California plant pathologist who confirmed that many of the bunch grapes grown at Meridan and Mississippi State University in the 1950s did have Pierce's disease (5). This disease probably was the limiting factor in grape production and poor longevity in Mississippi (10). Pierce's disease also has been acute in Florida (6,9).

Loomis was transferred to Fresno, California in 1965, and his bunch grape breeding materials were dispersed. The USDA released all rights to their Mississippi grape selections to MAFES.

The director of MAFES approved maintenance of the "residual" selections at Mississippi State University by authorizing planting of a one-acre vineyard in 1965. Many selections soon were discarded because of poor vine vigor and/or poor fruit qualities. Some of the better selections were propagated by cuttings and were reestablished in 1974 as replicated or observation plots in the new MAFES vineyards at Beaumont and Crystal Springs (Figure 1).

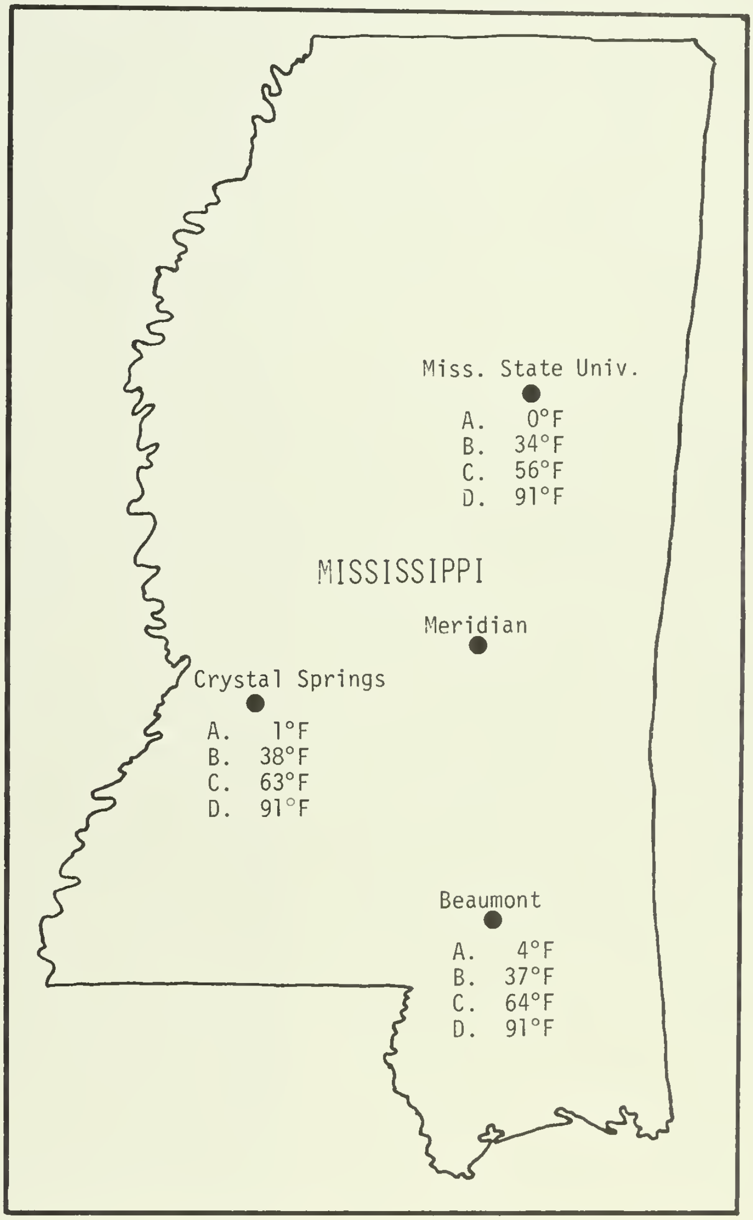

Figure 1. Locations where 'MissBlanc' bunch grapes have been tested.
A. Minimum winter temperature (Nov.-Feb.) 1974-1982.
B. Average daily minimum winter temperature.
C. Average daily maximum winter temperature.
D. Average daily maximum summer temperature (June-August).

Selections have been under MAFES testing for more than 15 years and have not died from Pierce's disease or other causes. A few of the surviving vines had good vigor, yields and reasonable resistance to fungal diseases under a good spray program. Two blue fruited cultivars were released in 1981 as 'MidSouth' and 'MissBlue' (7). Many American bunch grape cultivars still cannot be grown in Mississippi because of susceptibility to Pierce's disease or lack of environmental adaptation.

Origination of MissBlanc (Tested as M26-4D)

Parents of MissBlanc were 'Galibert 261-12' and a seedling of (Extra x Marguerite). Extra was originated by T. V. Munson (7) in 1886 at Denison, Texas by crossing *Vitis lincecumii* cv 'Beg Berry' x 'Triumph' (a cultivar with golden berries and *V. labrusca* x *V. vinifera* parentage). Extra is a purple-fruited grape with big berries and moderately compact bunches and is self-fertile. It was the leading bunch grape (known as 'Florida Beacon') in Florida from 1926 to 1935, when Pierce's disease and black rot susceptibility ultimately led to its rapid decline.

Marguerite was originated by T. V. Munson in 1896 from a cross of *V. lincecumii* cv 'Secundo' with 'Herbemont' (*V. bourquiniana*). Marguerite has medium-sized, compact and cylindical clusters with dark purple fruits and is resistant to Pierce's disease.

Galibert 261-12 was a French-American hybrid probably of the parentage 'Villard Blanc' x 'Semillon' (*V. vinifera*).

MissBlanc has perfect flowers and should be fully self-fertile, but has not been grown under isolated conditions by MAFES personnel. The berries are white to green in color. Clusters are shown on the front and in Figure 3.

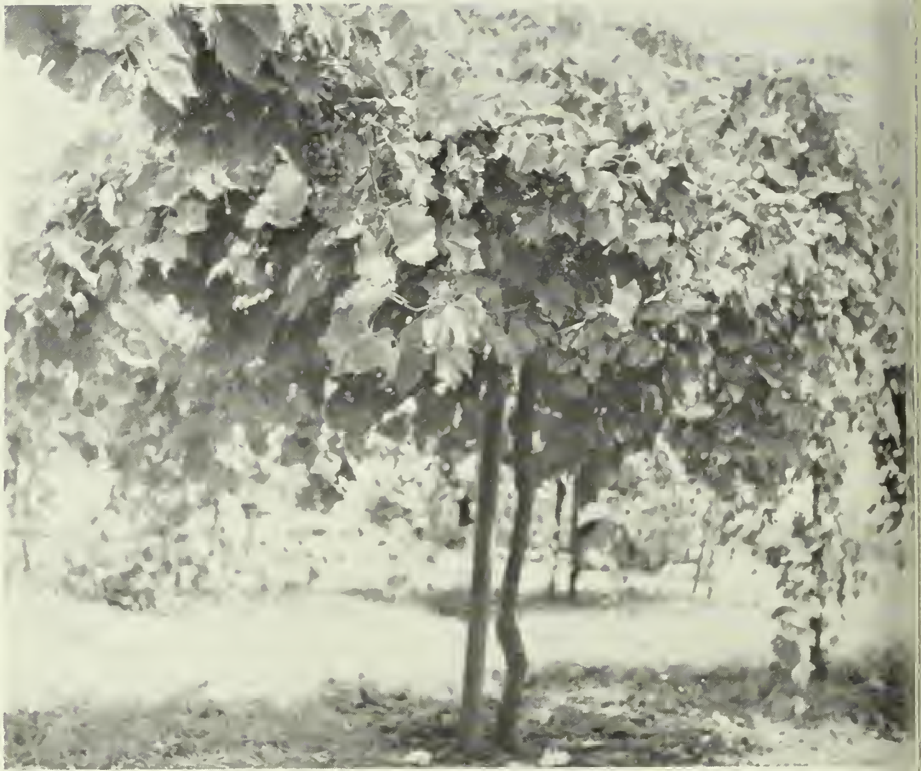

Figure 2. A vigorous, eight-year-old vine of 'MissBlanc' bunch grapes at the Truck Crops Branch Station at Crystal Springs in August 1981. This vine produced 60 pounds of grapes in 1981.

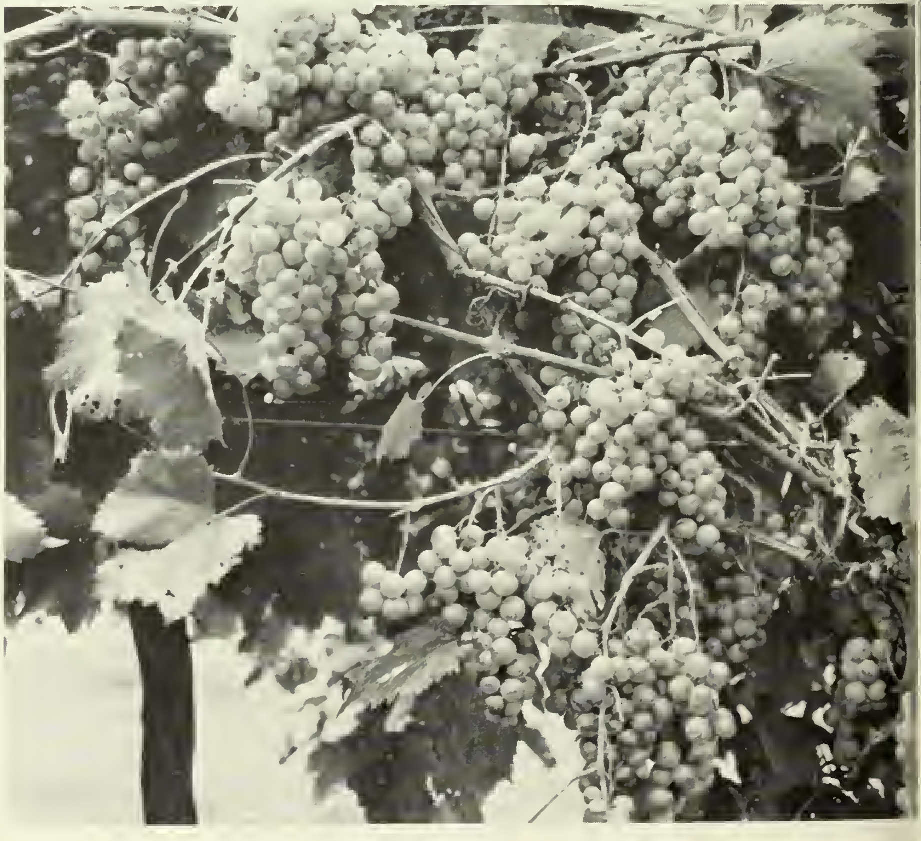

Figure 3. Heavy fruiting of a six-year-old 'MissBlanc' grapevine in the research vineyard of the Truck Crops Branch Station at Crystal Springs, Mississippi on August 7, 1979.

Vineyard Testing of MissBlanc

Characteristics of fruit of MissBlanc from the Crystal Springs ineyard were compared with hose of fruit of 'Lake Emerald' and hree blue bunch grape cultivars Table 1). The Florida cultivars, Blue Lake' and Lake Emerald, pparently are resistant to Pierce's isease, because they continue to ve and bear heavily even though many varieties such as Concord, Moored', 'Aurora', 'Chancellor' nd others have died (Table 2). MissBlanc produces medium-sized berries that are larger than berries of Lake Emerald. Cluster size of MissBlanc is smaller than that of Lake Emerald but larger than that of the blue cultivars. The sugar content of MissBlanc is less than hat of Lake Emerald but higher han that of the blue cultivars.

The primary superior characteristics of MissBlanc are general climatic adaptation and excellence plant vigor and yield Figures 2, 3). The vine shown in Figure 2 thrived for nine years under good vineyard management, which included a thorough fungicide spray program.

Vine vigor of MissBlanc in general was as good as that of MissBlue, MidSouth and Lake Emerald and was better than that of Blue Lake at Beaumont as recorded by annual prunings (Table 3) and trunk diameter measurements (Table 4) after five years in the vineyard.

Table 1. Fruit characteristics of grape cultivars at the MAFES Truck Crops Branch, Crystal Springs, Mississippi, 1976-1981 average.

Cultivar	Berries per pound*	Ounces per bunch	% sugars**
'Blue Lake'	226	3.7	17.5
'Lake Emerald'	378	5.4	21.5
'MidSouth'	189	3.7	18.6
'MissBlanc'	189	5.0	19.4
'MissBlue'	142	3.6	17.1

*Average of 30 berries from two or more samples for each of 6 years.

**Recorded with hand refractometer and corrected to actual readings for glucose and fructose at ambient laboratory temperatures.

Table 2. Bunch grape selections or cultivars with dead vines or vines of very poor vigor after four or five years[1] in the MAFES vineyards at Beaumont and Crystal Springs, Mississippi.

'Alwood'
Ark. 1023
Ark. 1026
Ark. 1052
Ark. 1140
Ark. 1221
'Aurora'
'Baco Noir'
'Chancellor'
'Concord'
'DeChaunac'
Ga. 19-23
'Moored'
'Rosette'
'Seyval'
'Vidal Blanc'

[1] Planted in 1973 or 1974 and evaluated in 1978.

Table 3. Weight of annual prunings from bunch grape vines in the MAFES vineyard at Beaumont, Mississippi, by cultivar, 1975-78.[1]

Cultivar	1975	1976	1977	1978	Mean total
	lbs/vine				
'Blue Lake'	1.2 a*	4.7 a	4.0 a	5.0 b	15.0 b
'MidSouth'	1.5 a	3.7 a	5.7 ab	8.7 a	19.7 ab
'MissBlanc'	1.5 a	5.0 a	5.2 ab	9.2 a	21.0 ab
'MissBlue'	1.0 a	3.5 a	9.0 a	11.2 a	24.7 a

[1] Four replicates of one-vine plots planted in 1974 (435 vines/acre).

*Numbers not followed by the same letter within columns are statistically different at 0.5 level.

Table 4. Trunk diameter of bunch grape vines at 36 inches above the soil, by cultivar.[1]

Cultivar	Trunk Diameter
	inches
'Blue Lake'	1.7 b*
'MidSouth'	2.3 a
'MissBlanc'	2.4 a
'MissBlue'	2.1 a

[1] Measured in fall 1977 after four years in the MAFES vineyard at Beaumont, Mississippi.

*Numbers not followed by the same letter are statistically different at .05 level.

Table 5. Dates of harvest of bunch grapes at the MAFES vineyards at Beaumont and Crystal Springs, Mississippi, by cultivar.[1]

Cultivar	Beaumont	Crystal Springs
'Blue Lake	8/8	8/13
'Lake Emerald'		7/31
'Midsouth'	7/31	7/31
'MissBlanc'	8/3	8/10
'MissBlue'	7/25	7/26
Average	8/1	8/3

[1] Dates are averages of three years.

MissBlanc ripens in late July to mid-August in south and central Mississippi (Table 5). The yield potential of these selections is shown in Figure 3 and Tables 6 and 7. The vine yields were recorded from plots with vine spacings of 10 x 10 feet.

Table 6. Yields of bunch grapes in the MAFES vineyard at Beaumont, Mississippi, by cultivar, 1976-78.[1]

Cultivar	1976	1977	1978	Mean Total 3 years
	----------	----------lbs/vine	----------	----------
'Blue Lake'	20.0 ab*	47.5 ab	9.5 cd	77.0 a
'MidSouth'	26.5 a	55.0 a	13.2 c	94.7 a
'MissBlanc'	4.0 bc	45.5 ab	26.7 b	76.2 a
'MissBlue'	18.7 abc	32.5 b	33.2 a	84.5 a

[1] 435 vines/acre and 4.6 lbs/vine = 2000 lbs/acre.

*One vine plots with four replicates. Numbers not followed by the same letters within columns are statistically different at 0.5 level.

Summary

MissBlanc grapevines have survived nine years in two vineyards where many other cultivars have died from Pierce's disease or lack of general climatic adaptation. Yields as high as 61 pounds per vine have been recorded at Crystal Springs. Based on 10 x 10 feet spacing (435 vines per acre), this is about 13 tons per acre. Commercial Concord vineyards in Arkansas average about 5 tons per acre.

Grapes of MissBlanc are sweet, mild and pleasantly flavored. Soluble solids are intermediate between Lake Emerald (high) and MidSouth or MissBlue (low), Table 1. MissBlue and MidSouth had more than 15.0° Brix, which is the minimum standard acceptable by National Grape Cooperative (Welch brand red grape juice). Wines from MissBlanc have been judged intermediate in quality for white wines made in Mississippi. It might be useful for blending to moderate the acidity and/or ta nin content of southern-ma wines because the flavor is mil Wine analyses are shown in Tab 8.

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Table 7. Yields of bunch grapes in the MAFES vineyard at Crystal Springs, Mississippi, by cultivar, 1977-79.[1]

Cultivar	1977	1978	1979	Total
	lbs/vine			
'Blue Lake'	4.3 d*	37.0 b	46.3 b	87.7 a
'MissBlanc'	16.0 b	52.0 a	61.0 a	129.0 a
'MissBlue'	10.2 c	33.3 b	67.5 a	111.0 a
'MidSouth'	13.0 bc	45.7 ab	55.3 ab	114.0 a
'Lake Emerald'	30.0 a	33.8 b	46.5 b	110.3 a

[1] One vine plots with four replicates planted in 1974. 435 vines/acre and 4.6 lbs/vine = 2000 lbs/acre.

*Numbers not followed by the same letter within columns are statistically different at .05 level.

Table 8. Composition of wines from bunch grapes from the MAFES vineyards, by cultivar.

Analysis	'MissBlue'	'MidSouth'	'Lake Emerald'	'MissBlanc'
ph	3.30	3.40	4.08	3.31
Total titrat. acid, %	0.895	0.832	.551	.550
Ions (ppm):				
Copper	-	-	0.5	0.2
Iron	-	-	6.3	8.5
Zinc	-	-	0.5	0.5
Ethanol, %/b.v.	10.4	12.2	12.4	12.4
Volatile acid, mb/100 ml	0.04	0.04	0.06	0.06

Acknowledgment

Acknowledged for their contributions to the testing of MissBlanc are Boyette Graves, Fruit and Vegetable Unit of MAFES South Mississippi Branch; W. A. Mulkey, formerly of Fruit and Vegetable Unit of South Mississippi Branch; W. O. Thomas, formerly of MAFES Truck Crops Branch; R. P. Vine, Mississippi State University McKay Food and Enology Laboratory and B. E. Waggoner, formerly of the Fruit and Vegetable Unit of the MAFES South Mississippi Branch.

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Bulletin 910

October 1982

Microbiological Characteristics of Vacuum-CO_2-Packaged Broiler Carcasses

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Poultry Scientist, Mississippi
State University, Poultry
Science Department

Microbiological Characteristics of Vacuum-CO_2-Packaged Broiler Carcasses

Bulk packaging of fresh broiler products (whole or part) in ice permits distribution from the South to major markets in urbanized areas throughout the United States, but shelf life of ice-packed poultry is short. Therefore, an alternative to ice packing is needed to (1) extend shelf life, (2) reduce transportation costs by replacing ice with salable products and (3) facilitate physical handling by eliminating melting ice.

Vacuum packing has been introduced as an alternative. Can[illegible]oni and Bolther (1973) identified several advantages of vacuum packaging, including reduction in weight loss due to dehydration, preservation of muscle color in its freshest state and elimination of external contamination. In addition, vacuum packaging improves organoleptic acceptability of ground beef (Jaye *et al.*, 1962).

Arafa and Chen (1975) observed that vacuum packaging of cut-up fresh broilers did not prolong shelf life during refrigerated storage. Microorganisms responsible for the spoilage of vacuum-packed, cut-up fresh broilers were members of *Enterobacter* species, and large numbers of *Pseudomonas* species were found in control samples.

Treatment with carbon dioxide (CO_2) is another way to improve packaging. CO_2 in the environment selectively inhibits growth of bacteria. Researchers have found that a combination of low temperature (0-10°C) and CO_2 in a controlled environment effectively extends the shelf life of red meat (Baran *et al.*, 1970), poultry (Wabeck *et al.*, 1968) and pork (Adams and Huffman, 1972). Recently, Sander and Soo (1978) reported that substituting 95% CO_2 for the air in packages of fresh broilers limited the growth of aerobic and anaerobic microorganisms. They indicated that packaging broiler carcasses in Nylon/Surlyn film with carbon dioxide addition rates of 3.6×10^{-4} and $7.22 \times 10^{-4} m^3/kg$ carcass, respectively, extended shelf life to 22 and 27 days at 1.1°C.

The purpose of this study was to evaluate the effect of vacuum-CO_2-packaging on the shelf life of broilers under two different storage temperatures.

Procedure

Sample Preparation and Storage

Ice packed and vacuum-CO_2-packed broiler carcasses (with giblet packages) were obtained from a commercial processing plant. The ice-packed samples were prepared by placing broiler carcasses directly into crushed ice. The vacuum-CO_2-packed samples were prepared by placing three broiler carcasses in 4.0 mil polyethylene pouches and sealing after drawing vacuum (44.4 cm or 17.5 in) and adding CO_2 at rates of 3.54×10^{-4} to $3.97 \times 10^{-4} m^3/kg$ carcass. Ten samples of each treatment were stored in -2.2 to 1.1°C and 1.1 to 3.3°C refrigerators in the Mississippi State University Poultry Science Laboratory. One sample from each storage condition was selected randomly for analysis at each testing period. Experiments were repeated.

Drip Measurement

The vacuum-CO_2 packages were cut at the corner and drained for 30 seconds. The drip was weighed and converted to a percentage of original carcass weight.

Sampling of Microorganisms

Carcass---Samples for microbiological study were obtained by swabbing the breast skin with a moist, sterile cotton swab (Falcon plastics, CA) for thirty seconds in a different direction. The skin area swabbed was 1 sq inch (6.45 cm^2) circumscribed by a sterile aluminum foil template. The cotton tip was broken into a serial dilution containing 10 ml of nutrient broth, and the solution was shaken vigorously to disperse the cotton swab and thoroughly mix the microflora.

Gizzard---The gizzard sample was weighed into a sterile, wide-mouth 250 ml Erlenmeyer flask. An equal weight of sterile nutrient broth was added, and the mixture was shaken vigorously for one minute.

Plate Counts:

Plate counts were made in duplicate by using standard method agar (BBL). Plates were incubated for 72 hours at 20°C to determine the psychrophilic counts. For anaerobic counts, anaerobic agar (BBL) was used, and plates were incubated for 48 hours at 37°C. Average counts from the duplicate plates were reported as the number of bacteria per cm^2 of skin surface or number of bacteria per gram of gizzard.

Coliform Most Probable Number (MPN)

Methods for the coliform test as

described by Thatcher and Clark (1968) were followed.

Psychrotrophic count plates of the zero time and spoiled carcasses were used for selecting isolates under the two packing conditions. Carcasses stored for 28 days at 1.1 to 3.3°C were used as spoiled samples. All colonies from plates containing 10 to 30 colonies were isolated without bias and were purified by a streak-plate technique.

Identification of Microorganisms:

The purified cultures were transferred to standard method agar slants and incubated at 20°C, and these fresh cultures were used for identification. Gram sta motility, oxidative and ferme tative metabolism, cytochro oxidase and catalase tests of the cultures were made according the methods described by Colli and Lyne (1970). The scheme Freeman *et al* (1976) was used identify the isolates.

RESULTS AND DISCUSSION

The log of total bacterial counts on 6.5 cm^2 of skin surface at 20°C, suggested by Elliott and Michener as a spoilage indicator, revealed that vacuum-CO_2-packed broiler carcasses spoiled after 21 days of storage at 1.1 to 3.3°C. Ice-packed samples stored under the same conditions spoiled after 14 days of storage. Lowering the storage temperature to -2.2 to 1.1°C extended the shelf life for the vacuum-CO_2-packed and the ice-packed broiler carcasses about five and four days, respectively.

The finding of longer shelf life for broiler carcasses in a CO_2 atmosphere agreed with the results of Killeffer (1930) and Coyne (1932). They determined that meat and fish products can be kept fresh longer when refrigerated in a CO_2 atmosphere. Our results supported the findings of Sander and Soo (1978) who indicate that, at storage temperature of 1.1° packaging broiler carcasses Nylon/Surlyn film with 3.6x10 and 7.22x10^{-4}m^3 CO_2/kg carca extended the shelf life eight to t days, respectively.

The growth of psychrotroph microorganisms (Figure 1) w delayed by the absence of a and/or the presence of 3.54x10^{-4} 3.97x10^{-4}m^3CO_2/kg carcass. Ps

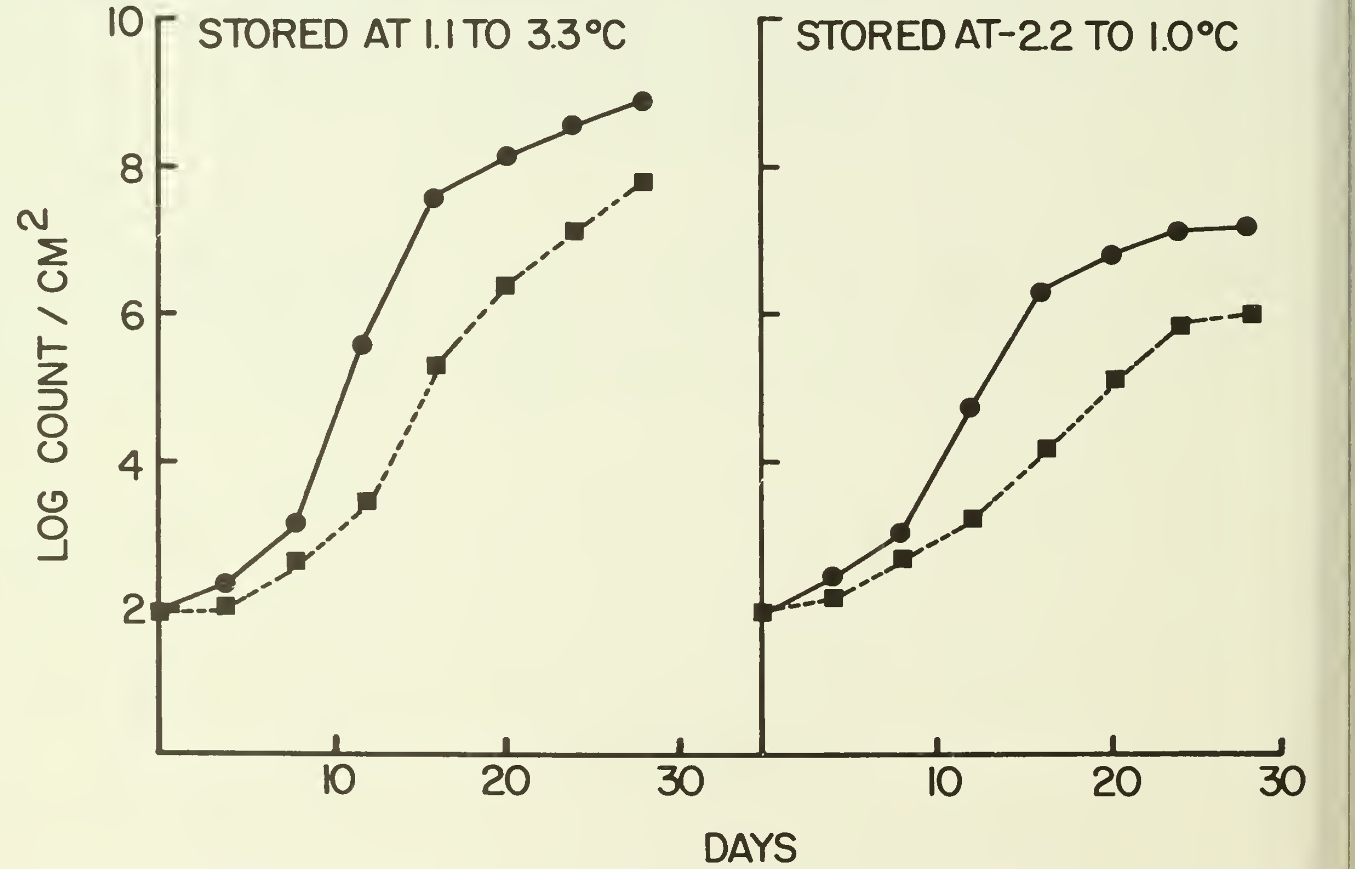

Figure 1. Psychrotrophic counts of vacuum-CO_2-packed ■ and ice-packed ● broiler carcasses.

hrotrophic counts were con- stently lower for the vacuum-O$_2$-packed samples than for the e-packed controls. A longer rowth lag phase was observed for he vacuum-CO$_2$-packed samples han for the ice-packed control. imilar trends were observed at oth storage temperature ranges. otal aerobic counts for both ackaging methods were lower for amples stored at -2.2 to 1.1°C than or those stored at 1.1 to 3.3°C. imilar trends were reported by Bailey *et al* (1979) for broilers tored at 2°C and 5°C.

The initial psychrophilic counts r both types of broiler carcasses were lower than those of the psychrotrophic counts (Figures 1 and 2); however, the psychrophilic counts were slightly higher than the psychrotrophic counts after 16 days of storage.

Anaerobic counts increased steadily for both treatments. Lower storage temperature resulted in lower anaerobic counts for the carcasses. Lower anaerobic counts were observed for the vacuum-CO$_2$-packed than for the ice-packed controls (Figure 3).

A log microbial count of 7.49/gram suggested by Charoenpong and Chen (1979) as detectable spoilage level for refrigerated gizzards, indicated that gizzards packed in giblet bags and stuffed in broiler cavities spoiled after 17 days of storage at 1.1 to 3.3°C. Log total counts/gram of gizzard were higher than log counts/cm^2 of the broiler skin. Thus, the vacuum-CO$_2$-packaging condition affected the growth of microorganisms on gizzards more than it did those of the carcass (Figures 1 and 4).

Under the same storage conditions, vacuum-CO$_2$ packaging extended the shelf life of gizzards in giblet bags about eight days beyond that of ice pack. Gizzard samples from the vacuum-CO$_2$-packaged carcasses stored at -2.2 to 1.1°C had counts of less than 1.4x10^5 cells/g of gizzard at 28 days of storage (Figure 4). No off-odor was detected for these gizzard samples.

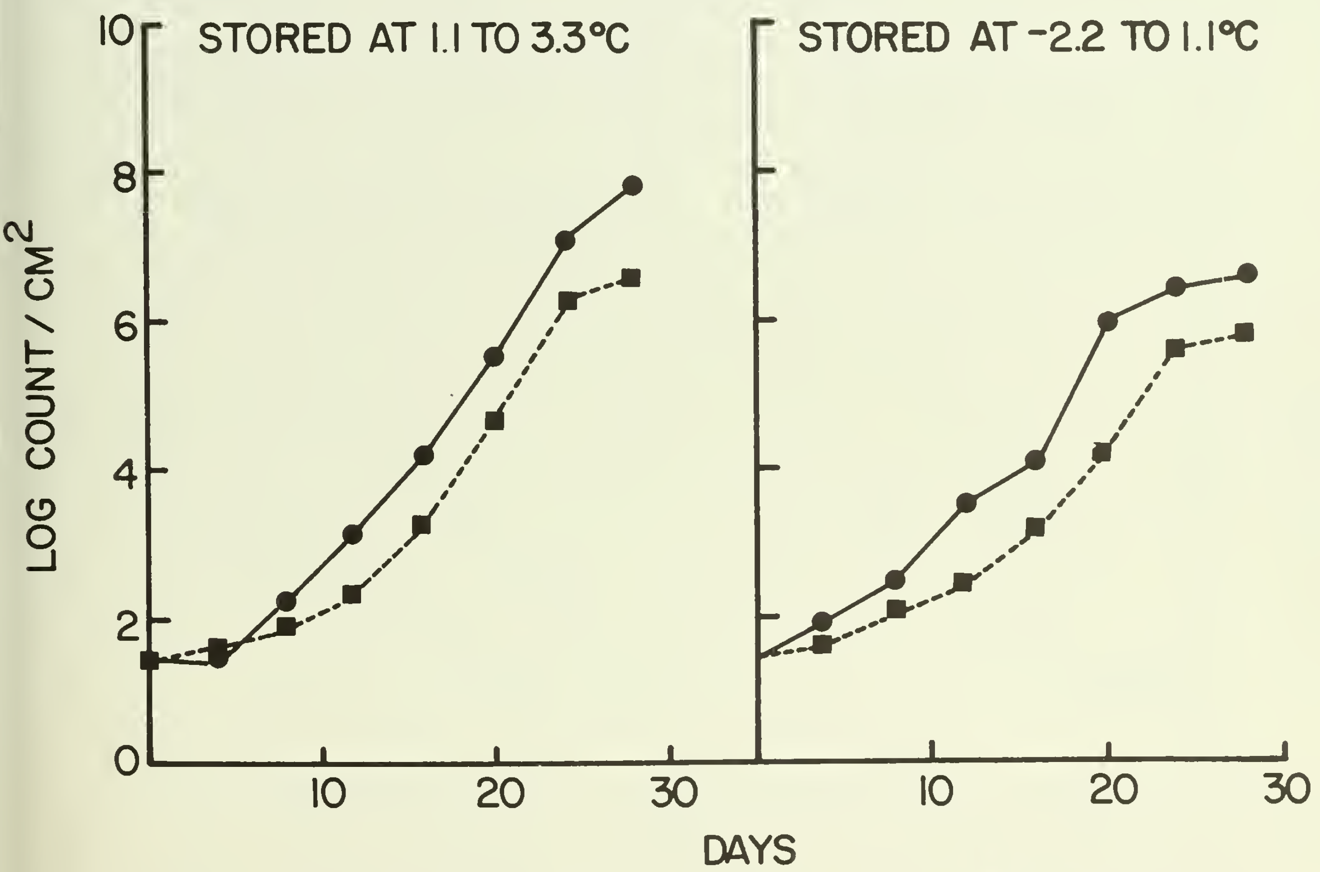

Figure 2. Psychrophilic counts of vacuum-CO$_2$-packed ■ and ice-packed ● broiler carcasses.

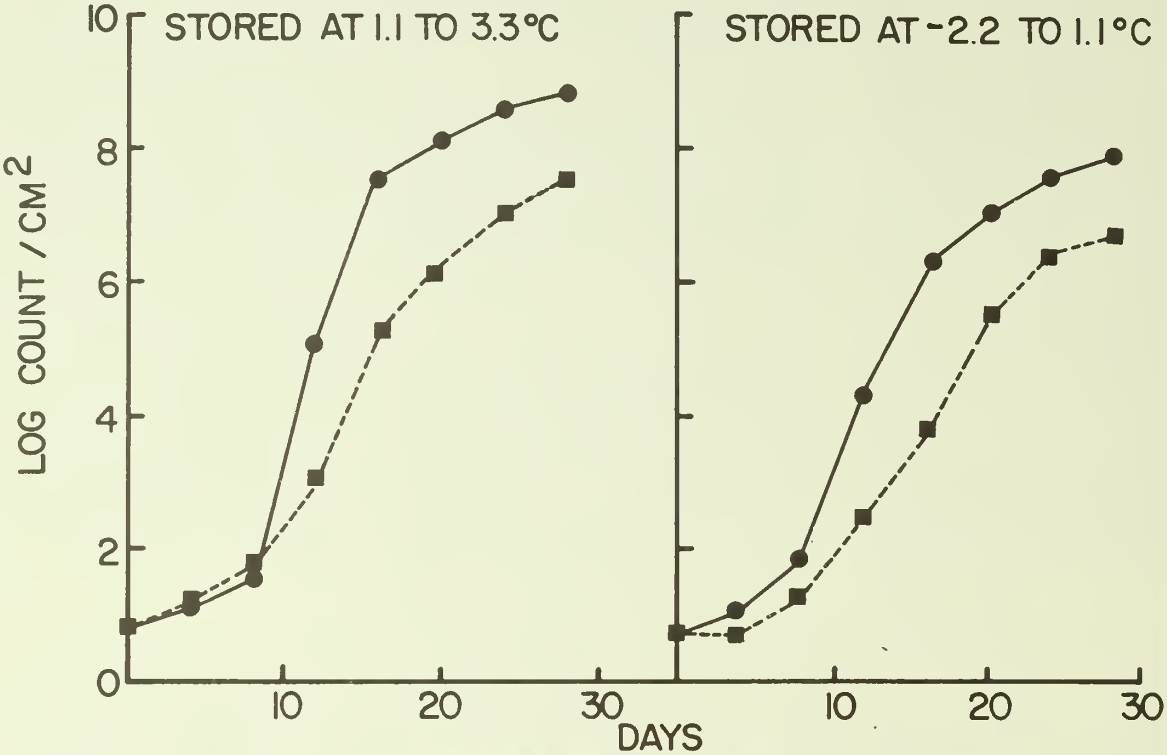

Figure 3. Anaerobic counts of vacuum-CO_2-packed ■ and ice-packed ● broiler carcasses.

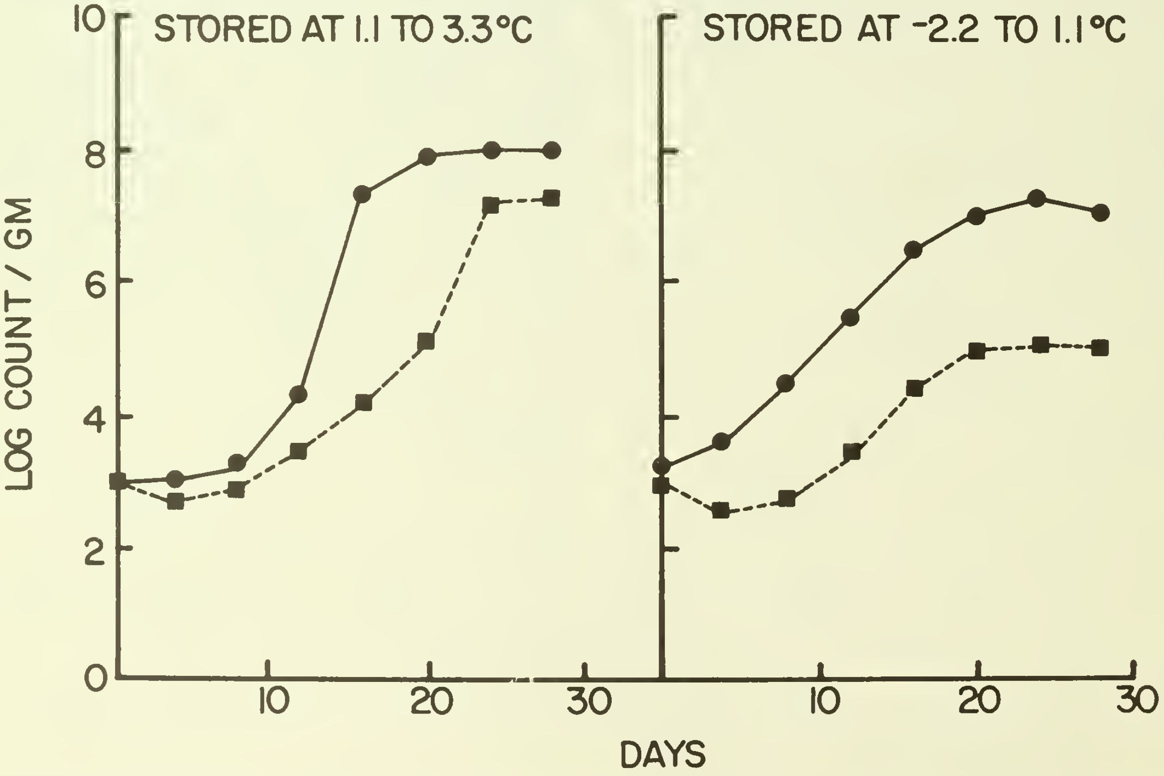

Figure 4. Psychrotrophic counts of vacuum-CO_2-packed ■ and ice-packed ● gizzards

The effects of storage emperature on the growth of nicroorganisms on gizzards liffered from the effects on broiler arcasses. The stationary phase nicrobial counts for the gizzards tored at -2.2 to 1.1°C were lower han those stored at 1.1 to 3.3°C, nd growth of microorganisms in ce-packed gizzard samples stored t -2.2 to 1.1°C was faster than on izzards stored at 1.1 to 3.3°C.

In most cases, the coliform IPN's of vacuum-CO_2-packaged amples remained low and were lightly higher than those of the ce-packed controls (Figure 5). The ata supported the findings of Vabeck *et al* (1968) and Arafa and hen (1976) but contradict those of Sander and Soo (1978), who indicated that coliforms grew rapidly on ice-packed chickens and that the presence of CO_2 significantly reduced the rate of growth.

Percentages of drip in vacuum-CO_2-packaged broiler carcasses increased slightly as storage time increased (Figure 6). Storage temperature affected the drip formation of packaged broiler carcasses. Vacuum-CO_2 – packaged carcasses stored at 1.1 to 3.3°C generally had similar or slightly higher drip percentages than those stored at -2.2 to 1.1°C. The increase in drip formation of vacuum-CO_2-packaged broiler carcasses was found to be greater than that reported by Lentz and Rooke (1958) and Baker (1959). These researchers indicated that the greatest loss of moisture under refrigerated storage of packaged broiler carcasses occurred within the first 2 hrs and stabilized ater 24 hrs. A slight reabsorption of drip was observed after 24 days of refrigerated storage at both temperatures. This reabsorption of drip agreed with Arafa and Chen (1978).

The incidence of major microbial species when broiler carcasses arrived in the laboratory was similar for the samples packed by both methods. Gram positive cocci were the dominant microorganism followed by members of *Acinetobacter* and oxidative

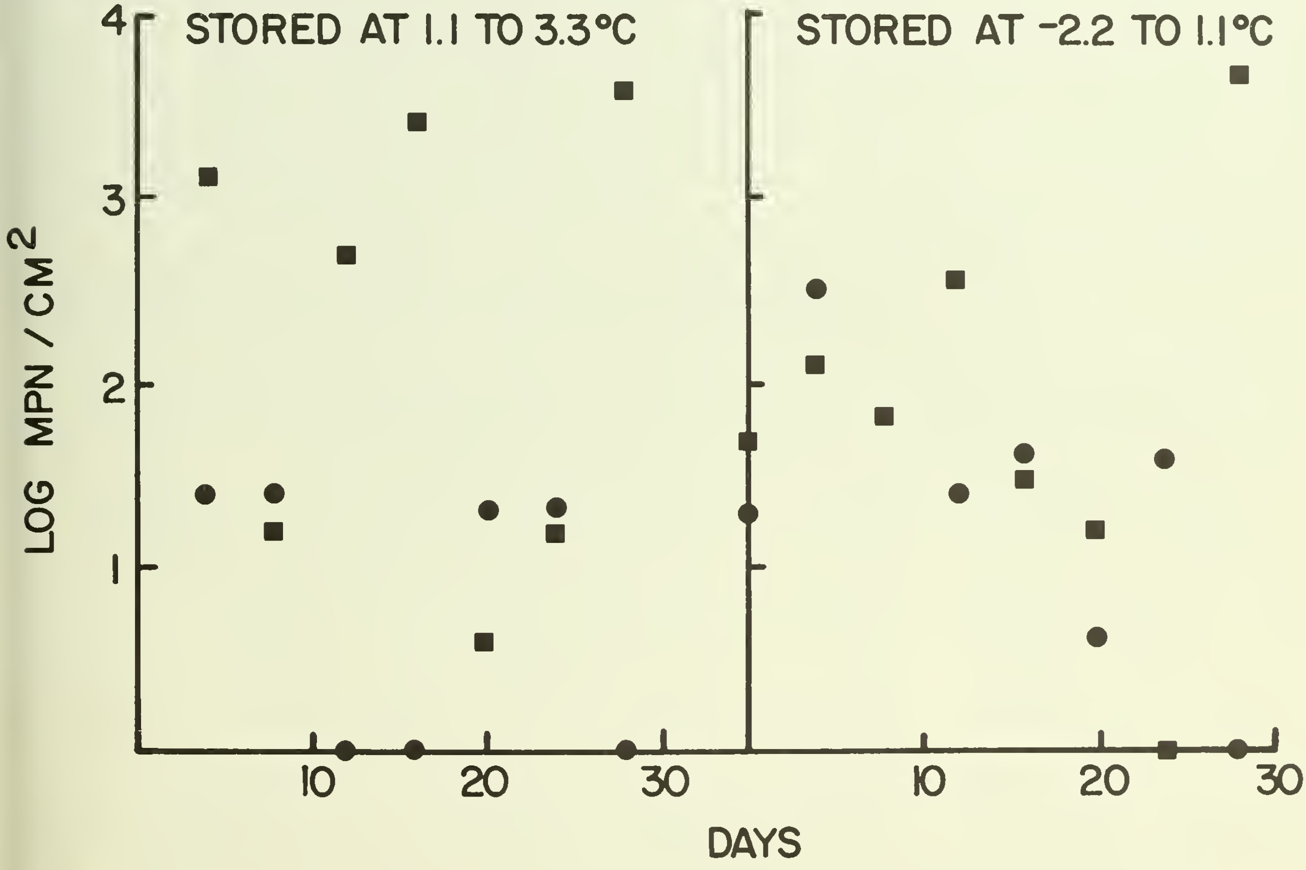

Figure 5. Coliform MPN of vacuum-CO_2-packed ■ and ice-packed ● broiler carcasses

Moraxella (Table 1). The vacuum-CO_2-packaged broiler carcasses had higher *Acinetobacter* counts than the ice-packed controls. In addition, no Gram positive rod type microorganisms, *Micrococcus, Pseudomonas* or fermentative *Flavobacterium* were isolated from the vacuum-CO_2-packed samples. Higher percentages of gram positive cocci on fresh broiler carcasses also were reported by Arafa and Chen (1977).

The initial incidence of the major microbial group was similar for the ice-packed and the vacuum-CO_2-packaged broilers, but major groups of microflora responsible for spoilage of these two types of broiler samples were different (Table 2). The major microbial groups isolated from the spoiled ice packaged samples were members of the *Pseudomonas* genus, but *Lactobacillus* species were found to be the dominant microflora on the vacuum-CO_2-packaged samples after 28 days of storage at 1.1 to 3.3°C.

Species of *Pseudomonas* also were isolated from the vacuum-CO_2-packaged samples after 28 days of storage at 1.1 to 3.3°C, but

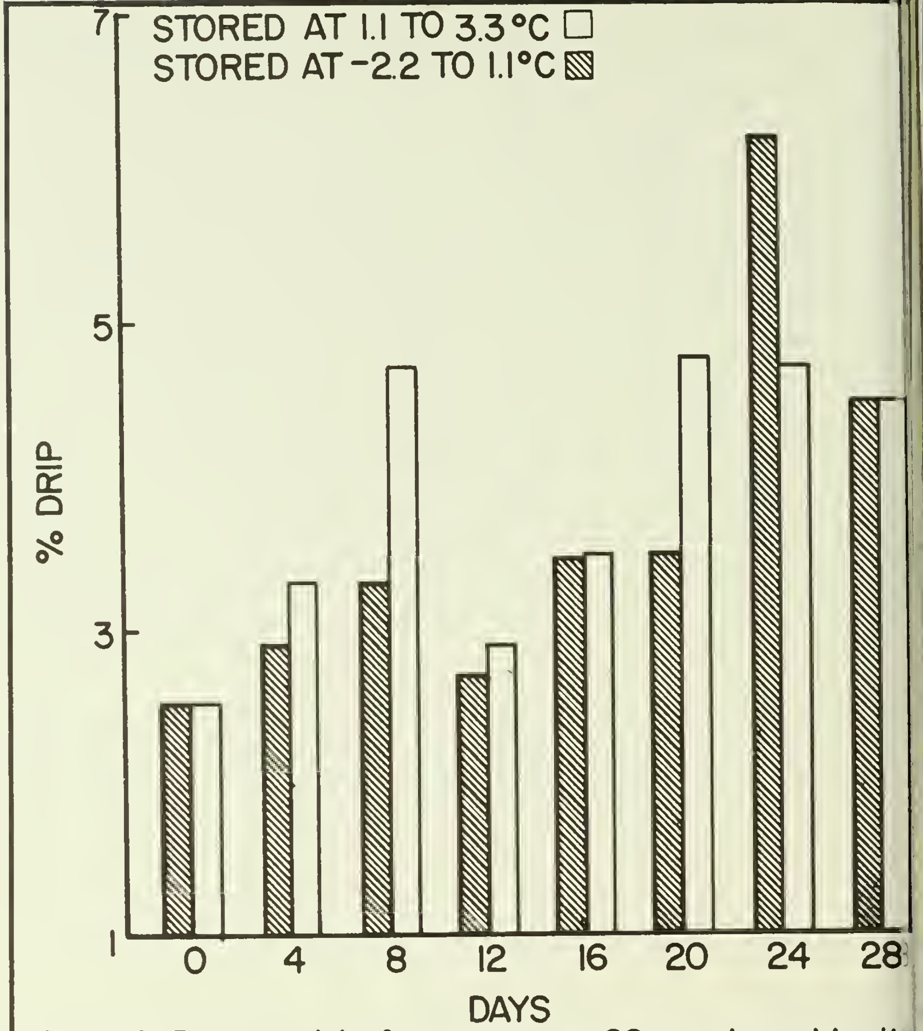

Figure 6. Percent drip from vacuum-CO_2-packaged broil
carcasses.

Table 1. Incidence of microflora on ice-packed and vacuum-CO_2-packed fresh broilers[1]

Gram-stain and Morphology	Ice packed No. of isolates	Ice packed % of isolates	Vacuum-CO_2 packed No. of isolates	Vacuum-CO_2 packed % of isolates	Microbial groups
G+ cocci	34	57.6	29	52.7	Staphylococcus
	31	52.5	29	52.7	Micrococcus
	3	5.0	--	--	
G+ rod	4	6.7	--	--	
	2	3.3	--	--	B (Lactobacillus sp.)
	2	3.3	--	--	Others
G- rod	21	35.5	26	47.2	
	2	3.3	--	--	E (Pseudomonas sp.)
	2	3.3	2	3.6	J (Moraxella)
	9	15.2	18	32.7	K (Acinetobacter)
	5	8.4	4	7.2	L (Moraxella - oxidative)
	1	1.6	--	--	M (Flavobacterium-fermentative)
	2	3.3	2	3.6	N (Flavobacterium)

[1] Microbial groups as described by Freeman et al. (1976) were followed.

Table 2. Incidence of spoilage microflora on ice-packed and vacuum-CO_2-packed,spoiled broilers[1,2]

Gram-stain and Morphology	Ice packed		Vacuum-CO_2 packed		Microbial groups
	No. of isolates	% of isolates	No. of isolates	% of isolates	
G+ rod	2	3.2	40	74.0	
	1	1.6	40	74.0	B (Lactobacillus sp.)
	1	1.6	-	-	Others
G- rod	59	96.7	14	25.9	
	57	93.4	12	22.2	E (Pseudomonas sp.)
	2	3.3	-	-	L (Moraxella-
	-	-	2	3.7	P (Putrefaciens)

[1] Samples were stored at 1.1 to 3.3°C for 28 days.
[2] Microbial groups as described by Freeman et al. (1967) were followed.

the percent incidence of *Pseudomonas* was much lower than for the ice-packaged samples (22.2% vs 93.4%). No oxidative *Moraxella* were isolated from the vacuum-CO_2-packaged samples. The high incidence of *Pseudomonas* species on the spoiled ice-packed broiler carcasses agreed with results reported by Wabeck *et al* (1968) and Arafa and Chen (1975). Arafa and Chen (1975) reported that 95.5% of the microorganisms in vacuum-packaged broiler parts after 28 days of storage at 2-4° were members of *Enterobacter* species while the other 4.1% were members of *Pseudomonas*. Results of this study indicated that the presence of CO_2 resulted in the growth of *Lactobacillus* species instead of *Enterobactor* species in the vacuum-CO_2- packaged broiler carcasses.

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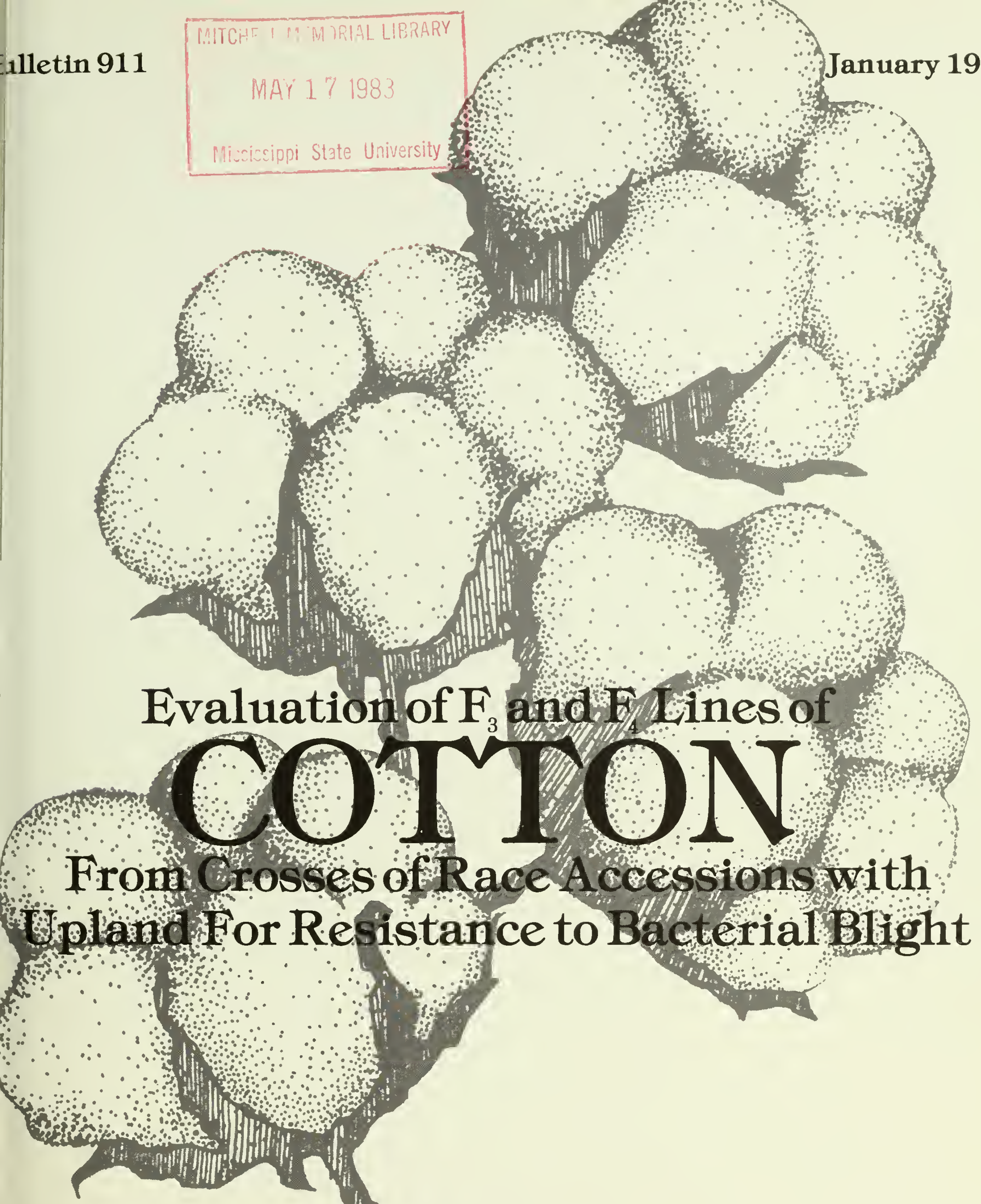

Evaluation of F_3 and F_4 Lines of COTTON From Crosses of Race Accessions with Upland For Resistance to Bacterial Blight

ARS, USDA
in cooperation with

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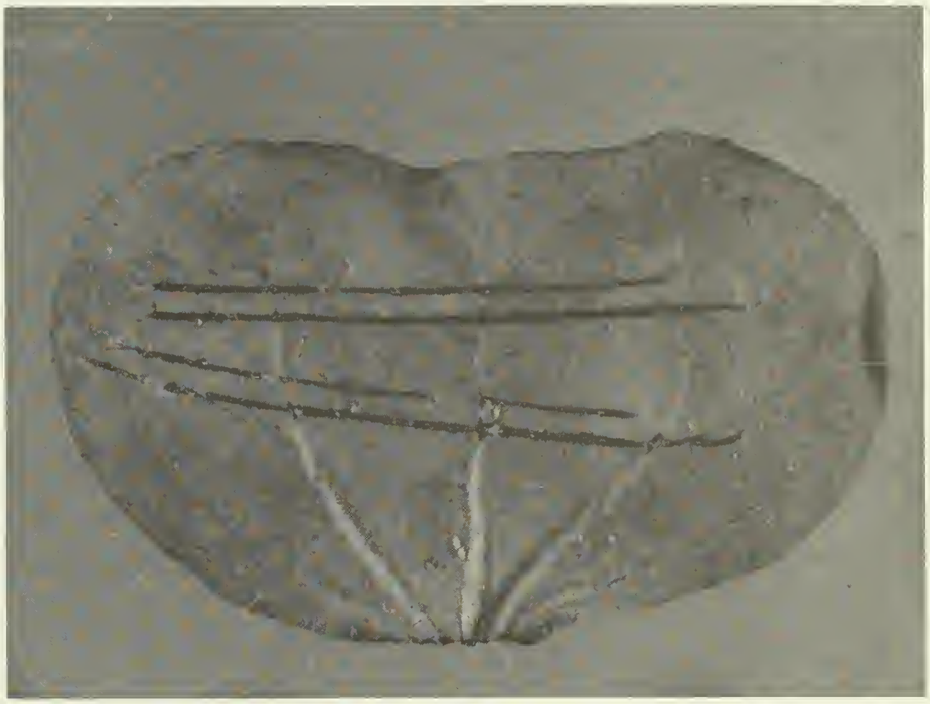
Evaluation of F_3 and F_4 Lines of Cotton From Crosses of Race Accessions with Upland For Resistance to Bacterial Blight

Evaluation of F_3 and F_4 Lines of Cotton From Crosses of Race Accessions with Upland for Resistance to Bacterial Blight

Eighty one lines of cotton, *ossypium hirsutum* L., con- aining germplasm from 54 rimitive accessions in the race ollection have been released Jenkins et al, 1979). The primitive ccessions were originally crossed s males with either 'Deltapine 16' DPL-16) and/or Lubbock Dwarf. he procedure for developing the owering lines and maintaining enetic diversity was presented by McCarty el al, 1979. Also, sixteen dditional lines with Fusarium wilt resistance have been released Jenkins et al, 1979).

In 1978 and 1979, 82 cotton lines nvolving 54 race accessions, 10 BC_2F_5 lines and 119 F_3 race ines were evaluated for bacterial blight (*Xanthomonas malvacearum* (E.F. SM)) esistance in greenhouse tests. The bacterial blight inoculum consisted of a mixture of Races 1, 2, 7, 10 and 18 in equal volumetric portions. Before mixing each race, inoculum was standardized to equivalent bacterial density (ca 4 x 10″ viable cells/ml) based upon colorimeter reading (Mahill et al, 1978). The experimental designs were randomized complete blocks replicated four times.

The lower epidermis of seedling cotyledons was inoculated when most of the tissues were fully expanded (10-13 days after planting). Speed Ball #B-6 pens with the prongs 1.5 mm apart were used to noculate the cotyledons. Visual blight ratings were recorded following maximum disease reactions, which occurred from nine to 13 days after inoculation (Mahill et al, 1978). A mean of the blight readings of six to ten plants per entry per replication was used as a disease grade for each experimental observation. The check cultivars used were 'Deltapine 61,' 'Stoneville 213' and GN-6-76. The disease grading scale is given in Table 1 (Mahill et al, 1978). Resistant and susceptible extremes of the grading scale are shown in Figure 1.



RESISTANT (Grade 2) ⇧ SUSCEPTIBLE (Grade 9) ⇩

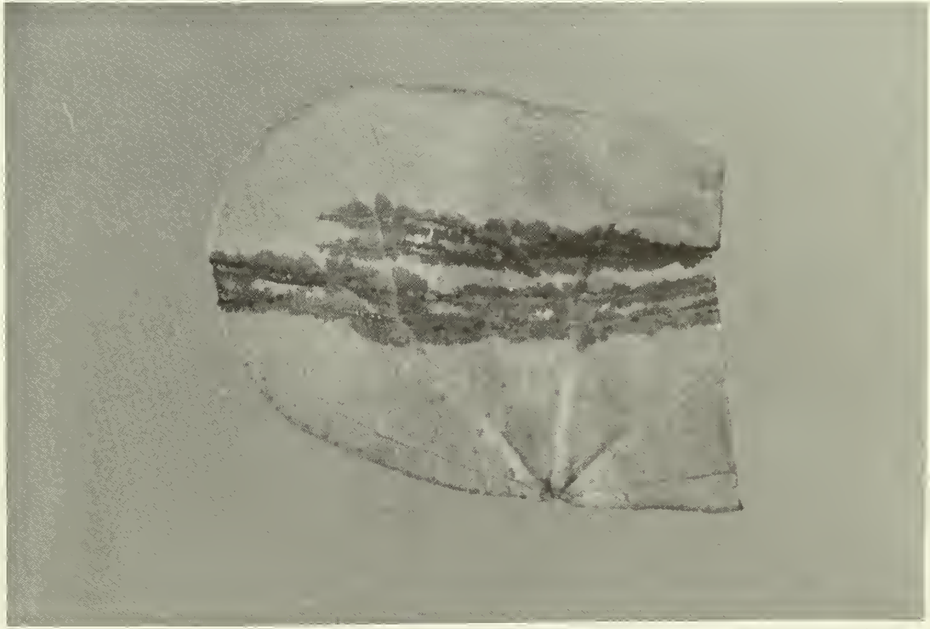


Figure 1. Resistant and susceptible extremes outlined in Table 1.

Table 1. Bacterial blight disease grading system used in greenhouse experiments with cotton.[1]

Resistance Level	Disease Grade	Description of affected tissues
Susceptible	9	Completely susceptible - excessive water soaking of tissue and lesions are spreading.
	8	Solid water soaking of tissue and spreading well.
	7	Solid water soaking of tissue, definitely outside the scratch marks with little or no spreading.
Intermediate	6	Solid water soaking, but only occasional spreading outside the scratch marks.
	5	Water soaking of tissues in the scratch marks.
	4	Very slight signs of water soaking of tissues.
Resistant	3	Tissue darkening with no signs of water-soaked tissue.
	2	Tissue brown with no signs of water-soaked tissue.
	1	Completely resistant - tissue is white or gray resembling scar tissue from the scratch.

[1] Mahill et al., 1978.

Evaluations of the 82 F_4 and 10 BC_2F_5 cotton lines (Table 2) showed that 11 lines were equal to and 30 lines were non-significantly less susceptible than Stoneville 213. Race stock lines with Lubbock Dwarf as female parent apparently were intermediate while their counterparts with DPL-16 as female parent were susceptible. In the F_3 lines (Table 3), resistance higher than that of DPL-61 or Stoneville 213 was not observed. In general, the blight grades for all the cotton lines formed a normal distribution around the commercial checks. This distribution indicates that the converted race stock lines of cotton exhibit minor gene effects and are near the same level as the commercial checks. Genes no more effective than the known minor genes probably ar involved. However, it is generall well known that major genes ar not effective unless combined wit compatible and complementar minor-modifier genes (Bird, L. S. personal communication). Th identification of minor-modifie genes could complement know major genes.

The technique of mixed inoculum f *X. malvacearum* races used in his study was considered to be the eason for no more than inermediate grades. However, the resence of single genes that may e effective against single races of he pathogen cannot be ruled out. The best cotton lines reported erein may exhibit resistance to pecific races.

Numerous primitive race accessions from diverse geographc origins were progenitors of the F $_3$ and F$_4$ cotton lines evaluated. Most were from Guerrero, Chiapas, and Oaxaco, Mexico, and Guatemala (Table 4). A high percentage of the lines originating from Chiapas and Oaxaca were intermediate in resistance to bacterial blight. A few lines from Hopi N. Mex. 1239, Hopi Mb-14-1-3, Belize, and from the Bahamas were more resistant than lines from other areas.

Predominately, the cotton lines had latifolium, punctatum, and morrilli race backgrounds (Table 5), and a large number of these were intermediate in resistance. A mean blight grade for morrilli of 6.3 (intermediate resistance) indicated a possible source of resistance in this cotton race.

Resistance to bacterial blight in this study was not associated with any cotton race or geographic origin. An increase in susceptibility over the upland parent apparently occurred in a few of the flowering lines. Cotton breeders should be aware of this response when using these exotic lines.

Our results tend to confirm previous research on bacterial blight (R. L. Knight, et al, 1950). According to Knight, the center of variability for the *G. hirsutum* species is in Central America. However, both Central and South America were poor areas for isolating cotton lines resistant to blackarm (bacterial blight). New-World strains of punctatum derived from Florida and the Bahamas showed resistance. In the data reported herein, two cotton lines from the Bahamas (Table 4) were intermediate in resistance.

Table 2. Bacterial blight resistance of the F$_4$ generation of 82 lines of cotton, Gossypium hirsutum L. (containing germplasm from 54 primitive races of cotton), and 10 BC$_2$F$_5$ lines of cotton.

Line[1/]	Female[2/] parent	Race[3/]	Site[4/] of original collection	Mean blight grades[5/]					Disease[6/] evaluation rating
				Test 1	Test 2	Test 3	Test 4	$\overline{X}$	
JPM-781-3-1	1	1	1		6.61 a-e	6.93 a-d		6.8	S
786-11-1	1	6	5	6.34 ab		6.77	6.39 a-c	6.5	S
786-11-2	2	6	5	5.81 b		5.99 b-j	5.78 a-d	5.9	I
782-25-1	1	2	3			6.73 a-g		6.7	S
782-26-1	1	2	3	7.51 ab		6.40 a-i		7.0	S
782-26-2	2	2	3	7.02 ab		5.96 d-j	6.07 a-d	6.4	I
781-59-1	1	1	3		7.29 a	6.65 a-h		7.0	S
781-66-1	1	1	3		6.73 a-d	6.45 a-i		6.6	S
781-66-3[7/]		1	3			6.18 a-j	6.16 a-c	6.2	I
781-69-1	1	1	4		6.34 a-g	6.64 a-h		6.5	S
781-69-3[7/]		1	4			6.92 a-d		6.9	S
781-75-1	1	1	4		6.64 a-e	6.87 a-e		6.8	S
781-75-3[7/]		1	4			6.21 a-j		6.2	I
781-78-1	1	1	4		6.35 a-g	5.86 f-j	5.91 a-d	6.1	I
781-84-1	1	1	4		6.11 a-g	6.47 a-i		6.3	I
781-84-3[7/]		1	4			5.93 e-j	5.78 a-d	5.9	I
781-87-1[7/]		1	4			6.41 a-i		6.4	I
781-88-1	1	1	4		6.91 a-c	6.53 a-i		6.7	S
781-88-3[7/]		1	4			6.28		6.3	I
782-94-1	1	2	4	7.60 ab		6.74 a-f		7.2	S
782-94-2	2	2	4	6.48 ab		6.19 a-j	6.11 a-d	6.3	I
781-100-1[7/]		1	4			6.30 a-j		6.3	I
781-103-1	1	1	4		6.91 a-c	6.96 ab		6.9	S

(Continued)

Table 2. (Continued)

Line[1]	Female[2] parent	Race[3]	Site[4] of original collection	Mean blight grades[5]					Disease[6] evaluation rating
				Test 1	Test 2	Test 3	Test 4	$\overline{X}$	
781-106-1	1	1	4		6.54 a-f	6.63 a-i		6.6	S
781-109-1	1	1	5		7.22 a	6.76 a-e		7.0	S
781-113-1	1	1	4		6.90 a-c	6.60		6.8	S
781-113-3[7]		1	4			5.93 e-j	5.96 a-d	5.9	I
781-118-1	1	1	4		6.50 a-f	6.78 a-f		6.6	S
781-158-1[7]		1	4			6.33 a-j		6.3	I
781-159-1	1	1	5		6.99 ab	6.65 a-h		6.8	S
781-185-1	1	1	4	7.13 ab		6.61 a-i		6.9	S
781-185-2	2	1	4	6.21 ab		5.98 c-j	5.51 b-d	5.9	I
786-194-1	1	6	5	6.62 ab		6.29 a-j	5.70 a-d	6.2	I
786-194-2	2	6	5	6.72 ab		5.89 f-j	6.05 a-d	6.2	I
781-195-1[7]		1	6			6.33 a-j		6.3	I
781-201-1	1	1	4		6.35 a-g	6.38 a-i		6.4	I
781-209-1	1	1	4		6.50 a-f	6.48 a-i		6.5	S
781-223-1	1	1	4		7.31 a	6.66 a-h		7.0	S
788-267-1	1	8	5	7.17 ab		6.30 a-j		6.7	S
786-292-1	1	6	5	7.41 ab		6.82 a-f		7.1	S
786-292-2	2	6	5	5.99 ab		6.39 a-i	5.73 a-d	6.0	I
786-295-1	1	6	5	7.73 a		6.54 a-i		7.1	S
786-295-2	2	6	5	6.08 ab		6.01 b-j	5.78 a-d	6.0	I
786-297-1	1	6	5	7.24 ab				7.2	S
786-297-2	2	6	5	6.29 ab		6.06 a-j	5.45 b-d	5.9	I
784-326-1	1	4	1	7.52 ab		6.60 a-i		7.1	S
784-336-1	1	4	1	7.30 ab		6.95 a-c		7.1	S
784-336-2	2	4	1		6.17 a-g	5.68 ij	5.62 b-d	5.8	I
788-339-1	1	8	1	7.17 ab		6.05 a-j	5.78 a-d	6.3	I
788-339-2	2	8	1		5.18 d-j	6.30 a-j	5.29 b-d	5.6	I
784-347-2	2	4	1		6.45 a-f	6.54 a-i		6.5	S
788-404-1	1	8	11	7.44 ab		6.62 a-i		7.0	S
788-404-2	2	8	11		5.57 b-g	5.68 ij	5.50 b-d	5.6	I
788-459-1	1	8	9	7.11 ab		6.22 a-j		6.7	S
788-459-2	2	8	9		5.18 d-g	6.40 a-i	5.64 b-d	5.7	I
785-461-1	1	5	5			6.43		6.4	I
782-488-1	1	2	8			6.34		6.3	I
782-495-1	1	2	9			6.64 a-h		6.6	S
782-495-3		2	9			6.26 a-j		6.3	I
788-679-1	1	8	9	7.59 ab		6.90 a-e		7.2	S
788-679-2	2	8	9		5.82 a-g	5.96 d-j	5.64 b-d	5.8	I
788-725-1	1	8	14	7.23 ab		6.65 a-h		6.9	S
788-730-1	1	8	7	7.42 ab		6.59 a-i		7.0	S
788-730-2	2	8	7		6.53 a-f	6.45 a-i		6.5	S
788-732-1	1	8	7	7.38 ab		6.68 a-h		7.0	S
788-732-2	2	8	7		5.80 a-g	6.16 a-j	4.98 d	5.6	I
788-759-1	1	8	12	7.36 ab		6.35 a-i		6.9	S
788-759-2	2	8	12		5.97 a-g	6.63		6.3	I
788-763-1	1	8	13	6.97 ab		6.68 a-h		6.8	S
788-763-2	2	8	13		5.85 a-g	6.38 a-i		6.1	I
788-764-1	1	8	13	7.39 ab		7.03 a		7.2	S
788-766-1	1	8	14	6.63 ab		6.13 a-j	6.00 a-d	6.3	I
788-766-2	2	8	14		5.75 a-g	5.76 g-j	5.63 b-d	5.7	I
788-786-1	1	8	14	7.16 ab		6.43 a-i		6.8	S
788-786-2	2	8	14		6.30 a-g	5.65 ij	5.80 a-d	5.9	I
788-790-1	1	8	14	7.23 ab		6.50 a-i		6.9	S
788-790-2	2	8	14		5.08 e-g	6.00 b-j	5.33 b-d	5.5	I

(Continued)

Table 2. (Continued)

Line1/	Female2/ parent	Race3/	Site4/ of original collection	Mean blight grades5/ Test 1	Test 2	Test 3	Test 4	$\bar{X}$	Disease6/ evaluation rating
788-805-1	1	8	15	6.26		6.20 a-j	6.27 a-c	6.2	I
788-805-2	2	8	15		4.98 fg	6.09 a-j	5.73 a-d	5.6	I
782-1045-2	2	2	9		6.50 a-f	6.13 a-j	5.93 a-d	6.2	I
788-1134-1	1	8	12	6.88 ab		6.34 a-i	6.06 a-d	6.4	I
788-1134-2	2	8	12		5.83 a-g	5.99 b-j	5.83 a-d	5.9	I
788-1149-1	1	8	9	7.05 ab		6.63 a-i		6.8	S
788-1149-2	2	8	9		4.87 g	5.42 j	5.26 b-d	5.2	I
788-1159-1	1	8	9	7.30 ab		6.66 a-h		7.0	S
788-1159-2	2	8	9		5.36 c-g	5.73 h-j	5.23 cd	5.4	I
788-1167-1	1	8	9	6.88 ab		6.10 a-j	6.25 a-c	6.4	I
788-1167-2	2	8	9		6.46 a-f	5.85 f-j	6.42 ab	6.2	I
788-1177-1	1	8	9	6.87 ab			6.79 a	6.8	S
788-1177-2	2	8	9		6.45 a-f		6.00 a-d	6.2	I
788-1180-1	1	8	9	7.08 ab			6.36 a-c	6.7	S
788-1180-2	2	8	9		6.74 a-d		6.14 a-c	6.4	I
DPL check				6.94 ab	6.27 a-g	6.53 a-i	6.00 a-d	6.4	I
STV 213 check				7.28 ab	5.80 a-g	6.10 a-j	5.87 a-d	6.3	I
GN-6-76 Resistant check						2.74 k	2.93 e	2.8	R

1/JPM-781-3-1: JPM = originators; 78 = year of germplasm release; 1 through 8 = race designation (1 = latifolium, 2 = punctatum, 4 = palmari, 5 = richmondi, 6 = morrilli, 8 = unclassified); 3 = accession number in ARS catalogue ARS-H-2, October 1974, the regional collection of Gossypium germplasm; 1 through 3 = serial release number from crosses involving this particular accession.

2/Female parent 1 was DPL-16; female parent 2 was Lubbock Dwarf.

3/Race Code 1 = latifolium; 2 = punctatum; 4 = palmari; 5 = richmondi; 6 = morrilli; 8 = unclassified.

4/Site of original collection of primitive races used in initial crosses: 1 = Guerrero, Mex; 3 = Chiapas, Mex; 4 = Guatemata; 5 = Oaxaca, Mex; 6 = El Salvador; 7 = Mexico; 8 = Yucatan, Mex; 9 = unknown; 11 = Hopi N. Mex. 1239; 12 = Veracruz, Mex; 13 = San Luis P. Mex.; 14 = Belize; 15 = Bahama Island.

5/Individual plants initially graded on a 1-9 scale (Table 1). Any 2 means within a test followed by the same letter are not significantly different based on Newman-Keul's Test.

6/Bacterial Blight Evaluation Rating, R = resistant (1.0-3.4), I = intermediate resistance (3.5-6.4), S = susceptible (6.5-9.0).

7/ BC_2F_5 (DPL-16 backcross parent) lines of cotton.

Table 3. Bacterial blight resistance of 119 F_3 lines from crosses of race stocks with Upland.

Race accession in cross	Race[1]	Site of original collection[2]	Mean blight grade[3]	Disease evaluation rating[4]
T-2	1	1	6.1 b-e	I
T-4	1	1	6.8 a-c*	S
T-6	1	2	6.0 c-e	I
T-7	1	2	6.5 a-e	S
T-16	1	3	6.9 a-c*	S
T-17	1	3	7.2 a*	S
T-21	1	3	6.3 a-e	I
T-22	1	3	6.2 b-e	I
T-24	1	9	6.1 b-e	I
T-30	1	3	6.6 a-e	S
T-31	1	3	6.7 a-d	S
T-33	1	3	6.7 a-d	S
T-34	1	3	6.1 b-e	I
T-35	1	3	6.9 a-c*	S
T-36	1	3	5.9 de	I
T-37	1	3	6.8 a-c*	S
T-38	1	3	6.5 a-e	S
T-39	1	3	6.2 a-e	I
T-40	1	3	6.9 a-c*	S
T-43	1	3	6.2 a-e	I
T-48	1	3	6.2 a-e	I

(Continued)

Table 3. (Continued)

Race accession in cross	Race[1/]	Site of original collection[2/]	Mean blight grade[3/]	Disease evaluation rating[4/]
T-50	1	3	6.6 a-e	S
T-56	1	3	6.3 a-e	I
T-57	1	3	6.0 b-e	I
T-58	1	3	6.3 a-e	I
T-60	1	3	6.4 a-e	I
T-61	1	3	6.7 a-d	S
T-62	1	3	6.4 a-e	I
T-63	1	3	6.3 a-e	I
T-64	1	3	5.8 de	I
T-65	1	3	6.0 b-e	I
T-67	1	3	6.4 a-e	I
T-68	1	4	6.2 b-e	I
T-71	1	4	6.5 a-e	S
T-72	1	4	6.4 a-e	I
T-73	1	4	6.5 a-e	S
T-74	1	4	6.3 a-e	I
T-77	1	4	6.4 a-e	I
T-79	1	4	7.0 ab*	S
GN-6-76 Resistant CK			2.7 f	R
DPL-61 CK			5.8 de	I
ST213 CK			5.7 e	I

(Continued)

Table 3. (Continued)

Race accession in cross	Race1/	Site of original collection2/	Mean blight grade3/	Disease evaluation rating4/
T-82	1	4	6.5 a-d	S
T-83	1	4	7.2 a-d	S
T-85	1	4	6.2 a-d	I
T-89	1	4	6.3 a-d	I
T-90	1	4	6.6 a-d	S
T-93	1	4	5.9 b-d	I
T-97	1	4	6.6 a-d	S
T-98	1	4	6.1 a-d	S
T-101	1	4	6.2 a-d	I
T-103	1	4	6.8 a-d	S
T-108	1	5	6.8 a-d	S
T-109	1	5	6.7 a-d	S
T-112	1	4	6.9 a-d	S
T-117	1	5	7.2 a-d	S
T-123	1	4	6.6 a-d	S
T-148	1	5	6.4 a-d	I
T-154	1	4	6.4 a-d	I
T-155	1	4	7.4 a-c	S
T-156	1	4	7.5 ab*	S
T-157	1	4	7.0 a-d	S
T-161	1	1	6.0 a-d	S
T-162	1	4	7.0 a-d	S

(Continued)

Table 3. (Continued)

Race accession in cross	Race[1/]	Site of original collection[2/]	Mean blight grade[3/]	Disease evaluation rating[4/]
T-164	1	4	6.1 a-d	I
T-170	1	4	7.0 a-d	S
T-173	1	4	6.5 a-d	S
T-177	1	4	6.6 a-d	S
T-178	1	4	6.4 a-d	I
T-180	1	4	7.1 a-d	S
T-182	1	1	6.9 a-d	S
T-183	1	1	6.6 a-d	S
T-188	1	4	6.8 a-d	S
T-197	1	4	6.5 a-d	S
T-199	1	4	6.8 a-d	S
T-205	1	1	6.7 a-d	S
T-206	1	1	6.7 a-d	S
T-208	1	4	6.3 a-d	I
T-212	1	5	7.2 a-d	S
T-213	1	6	6.5 a-d	S
T-214	1	6	6.3 a-d	I
T-215	1	6	7.0 a-d	S
T-216	1	6	6.8 a-d	S
T-217	1	4	6.3 a-d	I
T-218	1	4	6.7 a-d	S
T-221	1	4	7.2 a-d	S

(Continued)

Table 3. (Continued)

Race accession in cross	Race[1/]	Site of original collection[2/]	Mean blight grade[3/]	Disease evaluation rating[4/]
T-222	1	4	7.2 a-d	S
T-224	1	5	7.4 a-d	S
T-225	1	1	6.5 a-d	S
T-226	1	1	7.0 a-d	S
T-227	1	6	7.0 a-d	S
T-223	1	4	7.0 a-d	S
T-234	1	6	7.1 a-d	S
T-235	1	6	7.3 a-d	S
T-236	1	4	6.7 a-d	S
T-237	1	4	7.0 a-d	S
T-238	1	4	6.8 a-d	S
T-240	1	4	6.5 a-d	S
T-242	1	4	6.8 a-d	S
T-244	1	5	5.5 d	I
T-245	1	1	6.9 a-d	S
T-247	1	4	6.5 a-d	S
T-294	1	5	6.0 a-d	I
T-378	1	5	6.1 a-d	I
T-497	1	3	7.0 a-d	S
T-503	1	7	6.5 a-d	S
T-27	2	3	6.8 a-d	S
T-29	2	3	6.0 a-d	I

(Continued)

Table 3. (Continued)

Race accession in cross	Race1/	Site of original collection2/	Mean blight grade3/	Disease evaluation rating4/
T-45	2	3	6.7 a-d	S
T-165	2	4	6.5 a-d	S
T-251	2	4	6.5 a-d	S
T-488	2	8	6.4 a-d	I
T-10	8	5	7.1 a-d	S
T-32	8	9	6.6 a-d	S
T-149	8	4	6.8 a-d	S
T-150	8	6	6.7 a-d	S
T-151	8	4	6.9 a-d	S
T-399	8	10	6.1 a-d	I
T-404	8	11	6.4 a-d	I
T-459	8	9	7.2 a-d	S
T-570	8	9	7.7 a*	S
T-595	8	9	7.0 a-d	S
GN-6-76 Resistant Check			3.2 e	R
DPL-61 Check			5.9 a-d	I
ST213 Check			5.6 cd	I

* Significantly more susceptible than ST213.

1/ Race designation: 1 = latifolium; 2 = punctatum; 8 = unclassified.

(Continued)

(Continued)

2/ Site of original collection of primitive races used in initial crosses: 1 = Guerrero, Mex.; 2 - Pueblo, Mex.; 3 = Chiapas, Mex.; 4 = Guatemala; 5 = Oaxaca, Mex.; 6 = El Salvador; 7 = Mexico; 8 = Yucatan, Mex.; 9 = Unknown; 10 = Hopi M6-14-1-3; 11 = Hopi N. Mex. 1239.

3/ Individual plants initially graded on a 1-9 scale (Table 1). Any 2 means within an experiment followed by the same letter are not significantly different based on Newman-Keul's test.

4/ Bacterial blight evaluation rating, R = resistant (1.0-3.4), I = intermediate resistance (3.5-6.4), S = susceptible (6.5-9.0).

Table 4. Bacterial blight resistance of F_3 and F_4 lines, number tested, number grading interemediate resistance, and mean grade, by site of original collection of race accession progenitor.

Site of orginal collection	No. tested	No. graded intermediate	Mean blight grade
Guerrero, Mex.	17	4	6.6
Pueblo, Mex.	2	1	6.3
Chiapas, Mex.	36	18	6.5
Guatemala	65	18	6.6
Oaxaca, Mex.	24	11	6.5
El Salvador	8	1	6.9
Mexico	5	1	6.5
Yucatan, Mex.	2	2	6.4

(Continued)

(Continued)

Site of orginal collection	No. tested	No. graded intermediate	Mean blight grade
Hopi N. Mex. 1239	3	2	6.2
Hopi Mb-14-1-3	1	1	6.1
Veracruz, Mex.	4	3	6.3
San Luis P. Mex.	3	1	6.7
Belize	7	4	6.2
Bahama Island	2	2	5.9
Unknown	22	11	6.5
TOTAL	201	80	

Source: Tables 2 and 3

Table 5. Bacterial blight resistance of F_3 and F_4 lines, number tested, number graded intermediate resistance, and mean grade, by race progenitor.

Race	No. tested	No. graded intermediate	Mean blight grade
latifolium	122	41	6.6
punctatum	15	7	6.5
palmeri	4	1	6.5
richmondi	1	1	6.4
morrilli	10	6	6.3
unclassified	49	24	6.4
Total	201	80	

Source: Tables 2 and 3

Acknowledgment

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The Effect of Planting Date, Row Spacing and Variety on Soybean Yield in Mississippi

February 1983

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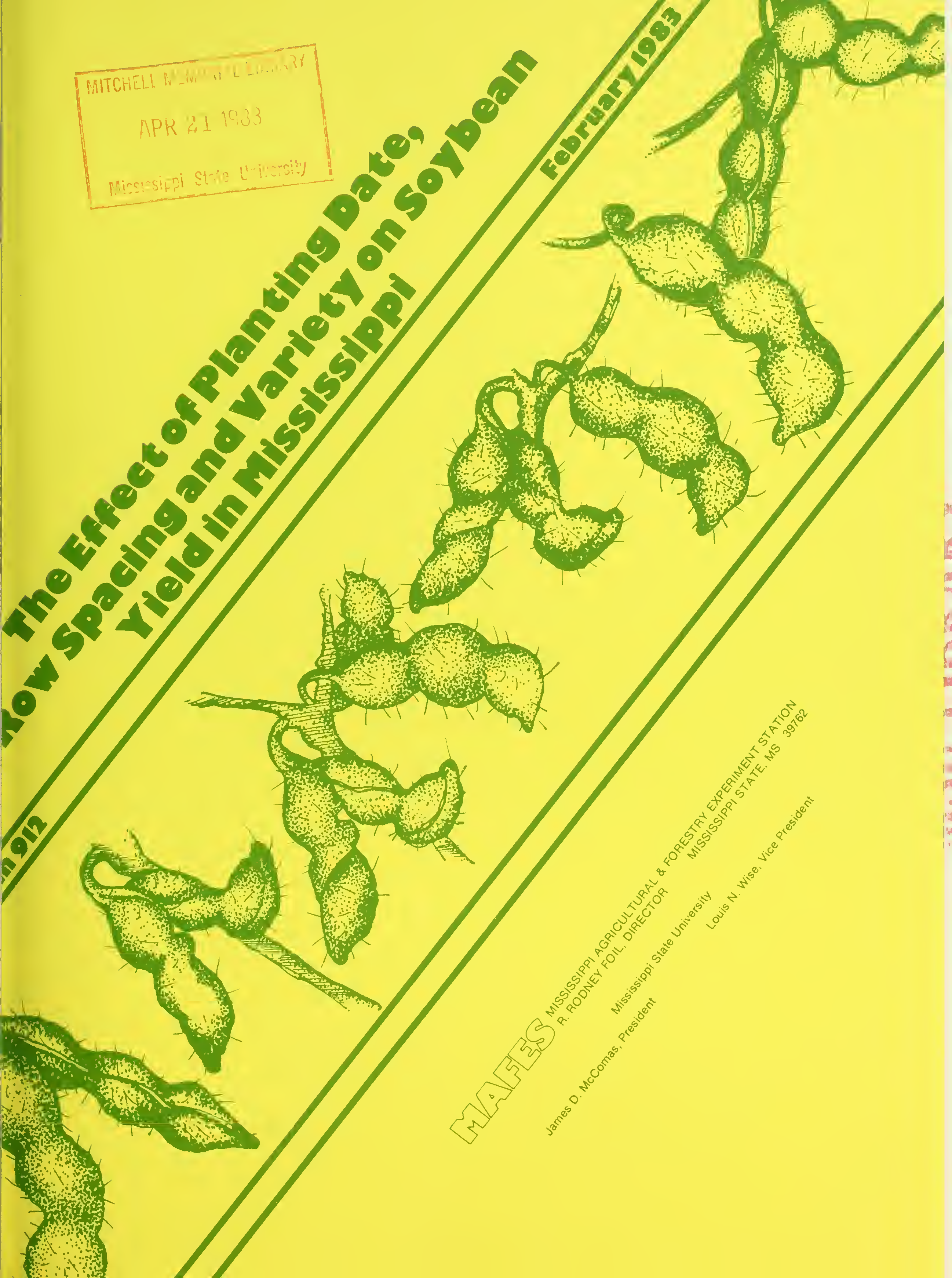

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The Effect of Planting Date, Row Spacing and Variety on Soybean Yield in Mississippi

The acreage and economic imrtance of soybean has increased pidly in Mississippi during reit years. The increase in acreage d numbers of producers has used some concern that ailable date-of-planting inforation is sometimes limited and t based on locally derived data. me have observed that working ys during which some soybean reage can be planted often are ailable in mid-April; however, formation available on the effect early planting on yields is nited.

Some soybeans in nearly every mmunity are planted in July ch year. During the ten-year riod (1969-78), 50% of the soybean reage in Mississippi was not anted by June 1, and 33% still as not planted by June 10 (Figure .

Soybeans are photoperiod sentive and the long days of late ne and early July in Mississippi event flowering while the shorter ys of late July and August cause owering. Planting too early uses premature flowering, and te-planted beans often are inuced to flower before the egetative factory" is large ough to supply adequate otosynthetic materials for opmum seed production. Belowormal yields normally can be xpected from beans planted too rly or too late.

National magazines have ported farmer experiences and ata from reputable scientists and nstitutions showing yield increase om narrow-row (solid-seeded) ybeans in the mid-West. Rowpacing data from Heatherly (peronal communication) on Sharkey lay at Stoneville, Mississippi, uggest that the greatest differences between 20- and 40-inch rows occurred when yield levels were relatively high and in seasons in which rainfall was well distributed. Adequate rain during the pod-filling period is thought to be especially important. These results are different from the findings in Indiana, Illinois and Ohio but are similar to results found in several experiments from other southern states (Egli, 1976 and Parker and Marchant, 1981).

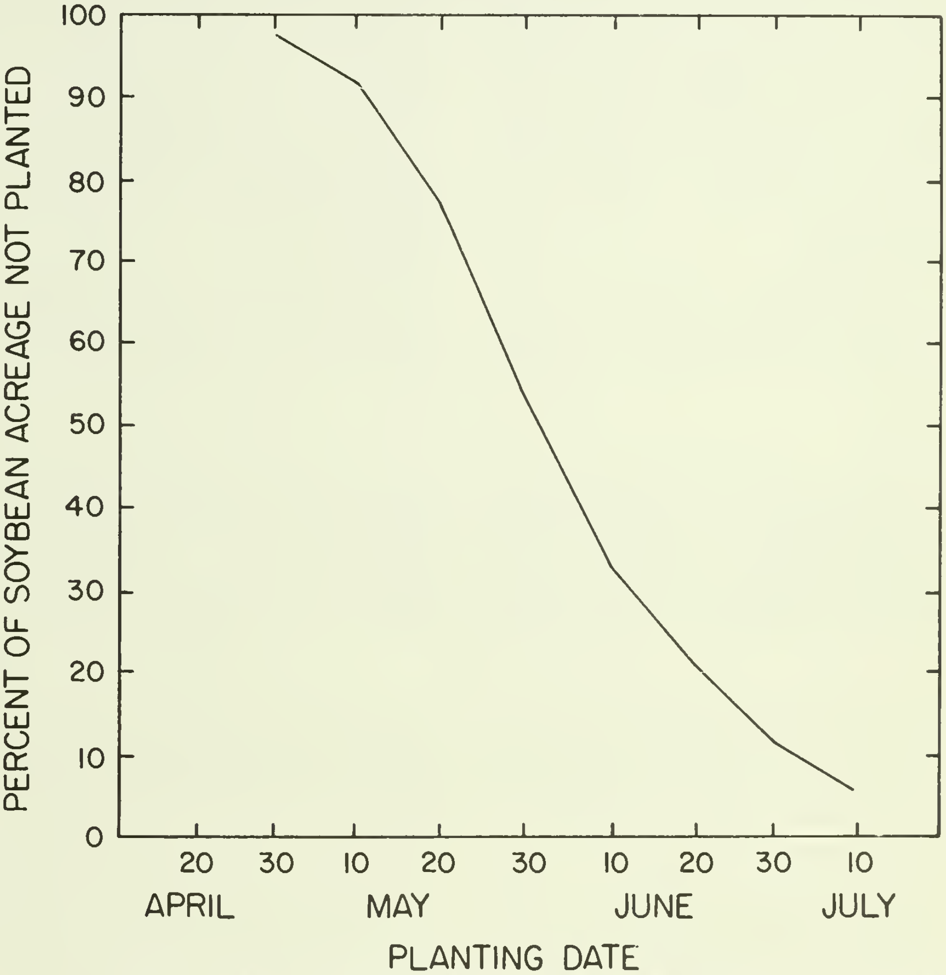

Figure 1. Percent of total Mississippi soybean acreage not planted by specified dates (1969-78 average).

Source: Mississippi Crop and Livestock Reporting Service, Mississippi Weather and Crop Report, (1969-78).

A row-spacing study at Holly Springs, Mississippi, in 1967 through 1970 found Lee and Bragg to yield slightly more in 20- than in 30- or 40-inch row spacings at most plantings. In 1967, the only year in which a very late planting was conducted, Lee produced 11.0, 7.4 and 5.2 bu/acre when planted in 20-, 30- and 40-inch rows, respectively.

The scarcity of information about the effect of date of planting and row spacing on the performance of determinant-type soybeans (such as those most widely grown in Mississippi) led to initiation of this study at five locations (Verona, Starkville, Brooksville, Raymond and Poplarville) in 1976. A sixth location (near Newton) was added to the study in 1977. These locations represent a diverse group of soil and climate regions in the non-delta section of Mississippi. The general soil characteristics by study areas are as follow:

Northeast Mississippi (Verona)---Silty clay loam soil, slowly permeable to water, primarily surface drained. High water table present through much of the year.

Blackbelt (Brooksville)---Clay to clay loam soil, shallow to chalk. The experimental site varies with 18 inches to chalk on one end of the field to about 12 inches on the other. The experimental plots were arranged so that each treatment received an equal number of plots on the deep as well as on the shallow soil

MAFES Plant Science Farm (Starkville)---Sandy clay loam soil, slowly permeable to water. Some evidence of plow pan. The site was deep chiseled before th crop year. High water tabl present through much of th year.

Coastal Plains (Newton)- Sandy loam soil, with plow pa 8-10 inches deep under norma cultivation. The soil was dee chiseled before the 1977 cro year.

Brown Loam (Raymond)- Deep silt loam soil, mino evidence of a genetic pan 20-2 inches deep.

South Mississippi (Popla ville)---Sandy loam soil ex cessively well drained.

Objectives

The objectives of the study were to determine (1) the optimum time to plant soybeans at each location, (2) the relative yield reduction one should expect by planting before and after the optimum planting season, (3) the optimum row spacing and the effect of planting date upon the response of soybeans to different row spacings and (4) the interaction of different maturi varieties with these manageme practices.

Procedure

The general plan followed at all locations was to begin planting soybeans on April 15 and plant at two-week intervals until July 1. Soil moisture at the various locations and in different years caused the planting schedule to vary. At some locations (e.g., Newton and Poplarville) there was only limited space available, and the numbers of planting dates were restricted.

Soil moisture at each location was monitored at different depths throughout the growing season. Considerable variation in rainfall from year-to-year and among locations was an important determinant of planting schedules. Appendix Table 7 presents the rainfall distribution throughout the growing season at each location and year.

Forty-, 30- and 7-inch row spacings were evaluated at all locations except Newton and Raymond where 40- and 7-inch spacings were evaluated. The 40- and 30-inch spacings were planted with a conventional planter, and the 7-inch spacings were planted with a grain drill. Manufacturers and models of equipment varied among locations. Planting rates were about 45 lbs of seed/acre when planted in 30- and 40-inch rows and about 60 lbs/acre when planted with the grain drills. Stand establishment generally was not a problem; however, stand establishment was poor in some of the late plantings when soil moisture was low and soil surface temperatures were high. Germination of the Hill seed was low in 1978, and poor stands resulted even though seeding rates were increased. Data are reported for plots where stands were reasonable but are not included in the statistical analysis.

Plots planted with a conventional planter were four rows wide except at Raymond where plots were eight rows (20-ft wide). Plots planted with a grain drill were 8- 10-ft wide at all locations. Leng of plots varied from 25 to 50 ft.

Pests were controlled as need and control varied consideral among locations and years. We control was generally satisfact to excellent except at Starkville 1978, Newton in 1979 and Popl ville in 1978 and 1979. A combi tion of cultivation and herbici was used on plots planted w conventional planters, and casional hand weeding was us on plots planted with a grain dr

The early-planted (mid and l April) beans were sprayed quently in early May to cont bean leaf beetle. Late-season sects (fall armyworm, velvet be caterpillar, the green clover wo and the cabbage looper) were serious problem at Brooksville a Starkville only in 1977. One ins ticide treatment controlled th pests in late July and early Augu however, large populations of c ge loopers and velvet bean caterillars developed in early eptember and seriously defoliated e late-planted soybeans at tarkville in 1977. The earlierlanted beans were damaged but ot completely defoliated by these sects.

The plots at Verona, Starkville, rooksville and Newton were arvested by hand in 1976 and ith a small-plot combine in 1977-9. Harvest at Poplarville was with small commercial combine in 976 and by hand in the other ears. The plots at Raymond were arvested with a field combine ach year. Beans from all handarvested plots were threshed with small stationary thresher. The wo center rows of plots planted ith a conventional planter and a trip 5-ft wide from plots planted ith a grain drill were combined.

The plots were laid out in a andomized three-split block esign with planting date the first plit, row spacing the second split and variety the third split. The Raymond trial was replicated three times, and trials at the other locations were replicated four times.

The data were summarized by years and subjected to Duncan's New Multiple Range Test. The over-years summaries were subjected to Student Newman Kuel's Test.

Results

Date of Planting

Data were summarized across all row spacings and varieties, but data for some years were excluded from the averages because of year-to-year variations in planting dates. There was little interaction of row spacings and planting dates or varieties and planting dates.

The highest yields at Verona, Starkville and Brooksville were from the late-April or early May plantings. The average reduction in yield observed for mid-April plantings compared to the optimum date (May planting) was about 15%. In contrast, mid- to late-June planting had an average yield reduction of 33%. Yields from beans planted in June and July were lower with each delay in planting date. A typical yield response to different planting dates is illustrated in Figure 2. Yields were highest from plantings in May and early June. Each day of delay in planting on 30-inch rows after June 10 resulted in a yield decrease of about 0.7 bu/acre/day. Yields of beans planted on 30-inch rows on June 10, 15 and 25 averaged 34, 30 and 24 bu/acre, respectively. However, beans planted on 30-inch rows in mid- and late-April produced 34 bu/acre or more.

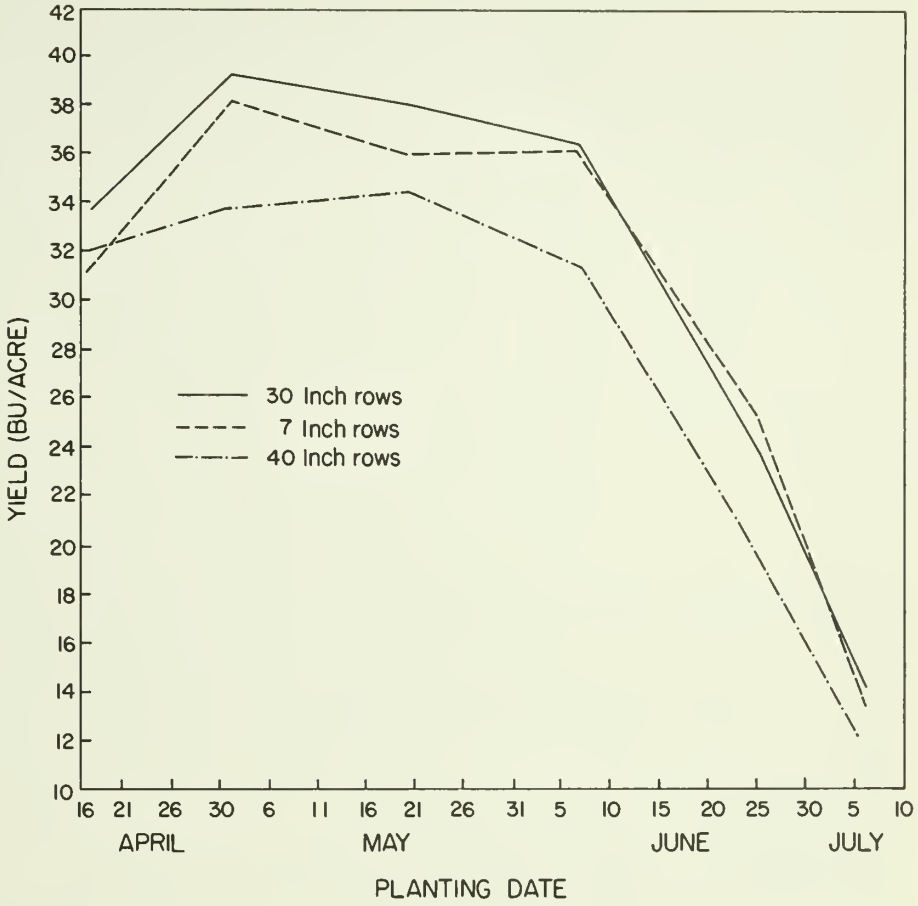

Figure 2. Four-year (1976-79) average yields of soybeans at Verona and Starkville (averages of Centennial, Forrest and Tracy, by row spacings and planting dates).

Results at Newton and Raymond were inconsistent (Table 1). Yields at Newton were lowest for beans planted in mid-April, but the highest average yield at Raymond was in plots planted April 19. Yield reduction from planting through May and until June 4 ranged from 1-17%, and reductions after June 4 were relatively steep with progressively later planting dates.

The limited data available from South Mississippi show results similar to those observed in North Mississippi. Days available for planting during any particular time period are limited because of the low water-holding capacity of the sandy soils at that location. Hence, there were fewer planting dates at Poplarville than at other locations.

Table 1. The effect of planting date on soybean yields, averages of all varieties and row spacings, by location, 1976-79.

Location																	
Verona			Starkville			Brooksville			Newton[1]			Raymond			Poplarville		
Planting Date	Bu/A	% Max.[2]	Planting Date	Bu/A	% Max.	Planting Date	Bu/A	% Max.	Planting Date	Bu/A	% Max.	Planting Date	Bu/A	% Max.	Planting Date	Bu/A	% Max.
April 16-20	29.9 C[3]	85	April 14-16	29.3 C	85	April 14-20	20.4 C	83	April 15-21	19.1 D	60	April·19	37.6 A	100	April 17-28	24.5 B	83
April 29-30	35.0 A	100	April 28-May 2	33.9 A	99	April 28-30	24.6A	100	May 2-3	23.2 C	73	April 27-May 5	32.9 B	88	May 11-18	29.6 A	100
May 19-24	32.8 B	94	May 16-24	34.3 A	100	May 15-20	22.9 B	93	May 16-28	31.9 A	100	May 19-24	37.2 A	99	June 6-18	25.2 B	85
June 6-13	32.6 B	93	May 30-June 8	31.1 B	91	June 1-5	20.8 C	85	June 6-14	27.1 B	85	May 28-June 14	31.1 B	83			
June 28-July 26	27.3 D	78	June 15-18	19.1 D	56	June 14-15	16.1 D	66				June 21-22	27.9 C	74			
			June 30-July 12	10.2 E	30	June 29-July 2	9.3 E	38				June 29-July 6	25.3 D	67			
						July 14-18	4.2 F	17				July 12-20	15.3 D	41			

[1] Results are from only three years of data (1977-79).

[2] Percent maximum yield at each location is percent of yield at the planting date with the highest average.

[3] Within each column, values followed by the same letter are not different at a probability level equal to or less than 0.05 as determined by the Student-Newman-Keul's Test.

Row Spacing

The row-spacing results are presented as averages over all planting dates, varieties and years (Table 2). Generally, there was no difference between the average yield of soybeans seeded with a grain drill in 7-inch rows and those planted in 30-inch rows. However, yields from the narrower spacings usually were greater than for beans planted in 40-inch rows.

The yield response (averages of the three highest-yielding varieties) to different row spacings at different planting dates at Verona and Starkville is presented in Figure 2. The data were summarized in this way because we suspected that the narrow row spacings would improve yields only in high-yielding situations. The 7- and 30-inch row spacings were generally higher yielding than the 40-inch row spacings. There was little interaction between row spacings and planting dates; however, the greatest differences among the row spacings were for May and June plantings, the least for April and July plantings.

Table 2. The effect of row spacing on soybean yields, averages of all varieties and planting dates, by location, 1976-79.

Row spacing (inches)	Location					
	Verona	Starkville	Brooksville	Newton[1]	Raymond	Poplarvill
	. . . .	. . . .	. . . .Bushels/Acre	. . . .	. . . .	. . . .
40	31.2 AB[2]	25.0 B	15.7 B	27.4 A	28.3 A	26.5 B
30	32.1 A	29.0 A	18.1 A	----	----	25.0 B
7	29.9 B	29.1 A	18.5 A	25.9 A	29.2 A	29.9 A

[1] Data for 1977-79 only.

[2] Within each column, numbers followed by the same letter are not significantly different at the 0.05 probability level as determined by the Student Newman Kuel Test.

The effect of planting date or variety on soybean yield response to row spacing was slight. There was a tendency for the latest-planted beans to yield better in the 7-inch spacing than in 30- or 40-inch spacings.

Varieties

Our data show that the intera tion between row spacings an planting dates was small. Th later-maturing varieties, Trac and Centennial, usually were th

Table 3. The effect of varieties on soybean yields, averages of all planting dates, row spacings and years, by location, 1976-79.

	Location					
Variety	Verona	Starkville	Brooksville	Newton[1]	Raymond	Poplarville
	. . . .	. . . .	.bushels/acre. . .	. . . .	. . . . .	. . . . . .
Hill	28.9 C[3]	22.9 C	14.8 B	23.9 B	24.1 B	19.8 E
Forrest	32.3 B	24.9 C	15.3 B	27.8 A	29.9 A	23.8 D
Tracy	35.7 A	30.6 A	19.6 A	28.7 A	29.3 A	--
Lee 74/Centennial[2]	34.6 C	30.9 A	19.1 A	--	32.0 A	--
Bragg	23.8 D	27.9 B	17.8 A	16.2 AB	28.3 A	29.7 B
Davis	--	--	--	--	--	28.7 B
Pickett	--	--	--	--	--	26.3 C
Cobb	--	--	--	--	--	32.5 A

[1] Data for 1977-79 only.

[2] Lee 74 was representative for this maturity group in 1976 at all locations except Starkville, Centennial was used in 1977-79.

[3] Within each column, values followed by the same letter are not different at a probability level to or less than 0.05 as determined by the Student-Newman-Kuel's Test.

ghest yielding of the varieties sted at all planting dates and row acings (Table 3).

Tracy had the highest yield and e lowest yield reduction when anted in early April. Yields of orrest, Centennial and Tracy veraged over the three northern cations were 22, 15 and 9% lower, spectively, from mid-April plantg than from planting at the ptimum time (Table 4). Forrest, an arly-maturing variety, generally ielded less in northern Mississippi hen planted in April; however, orrest yields were similar to yields f Tracy and Centennial when lanted in May and June. Bragg ielded less than the other varieties hen planted early; however, it is usceptible to stem canker, a disease that causes more damage to usceptible varieties when planted arly.

The general response of varieties planting date (photoperiod) is ne same, but some varieties are nore sensitive than others. The ata in Table 5 illustrate this. The nost nodes were developed on lants in plots planted in May. lanting earlier or later resulted in ewer nodes. Hill appeared to be nore sensitive than Tracy, and racy was more sensitive than ragg.

Table 4. Soybean yield and percent reduction at three planting dates (early, optimum and late), by variety and location,

		Location			
Planting Date	Variety	Northern Mississippi[1]		South Central Mississippi[2]	
		Bu/Acre	% Reduction from May 15-25	Bu/Acre	% Reduction from May 15-25
April 15-20	Hill	22	15	25	29
	Forrest	25	22	29	22
	Tracy	31	9	31	14
	Centennial	29	15	39	9
	Bragg	24	14	38	4
May 15-25	Hill	26	0	35	0
	Forrest	32	0	37	0
	Tracy	34	0	36	0
	Centennial	34	0	43	0
	Bragg	28	0	29	0
June 30-July 2	Hill	15	42	21	40
	Forrest	17	47	25	36
	Tracy	17	50	24	37
	Centennial	20	41	--	--
	Bragg	18	36	26	10

[1] Northern Mississippi data are averages of three row spacings at Verona, Brooksville, and Starkville over four years.

[2] South Central Mississippi data are averages of two row spacings at Raymond and Newton.

Plant Height

Plants at maturity (averages of all varieties tested at Brooksville in 1976) were slightly taller in the 7-inch spacing than in the 30- or 40-inch rows (Table 6). Plant height declined rather dramatically when soybeans were planted after mid-June.

Soil moisture

Soil-water changes at 6-inch intervals, beginning at 21 inches below the soil surface, in plots planted in early May are presented in Figure 3A. All depths dried rapidly soon after June 1 and were recharged to field capacity by a mid-June rain. From that point, there was a long dry period in which the 21-inch depth dried fastest and to the greatest extent. It appeared that the May-planted beans were capable of extracting water from deep in the soil. The soil was dried from the surface; i.e., the 6-inch layer centered at 21 inches below the surface dried before the 6-inch layer immediately below it, and that layer dried faster than the next deepest layer. Apparently, soil water was removed gradually from areas explored by roots as they grew progressively deeper.

Soil water changes did not differ ($P < .05$) among depth intervals on adjacent plots where beans were planted in July (Figure 3B). Apparently these late-planted beans were not capable of rooting sufficiently deep to remove significant amounts of water from any of the depths measured. This condition prevailed even though the surface soil was quite dry and the plants showed severe stress. Soil water content in the deeper strata (21 to 39 inches) was near field capacity during this period.

Morphogenetic development (growth stages)

Stages of development were monitored throughout the growing seasons at Starkville in 1978 and 1979 and in a similar experiment in 1980. (In the 1980 experiment, the same varieties as in previous years plus Bedford were planted April 30, May 12 and June 3. Later plantings were not made due to dry weather.) Dates of flowering were recorded as the time at which flowers appeared

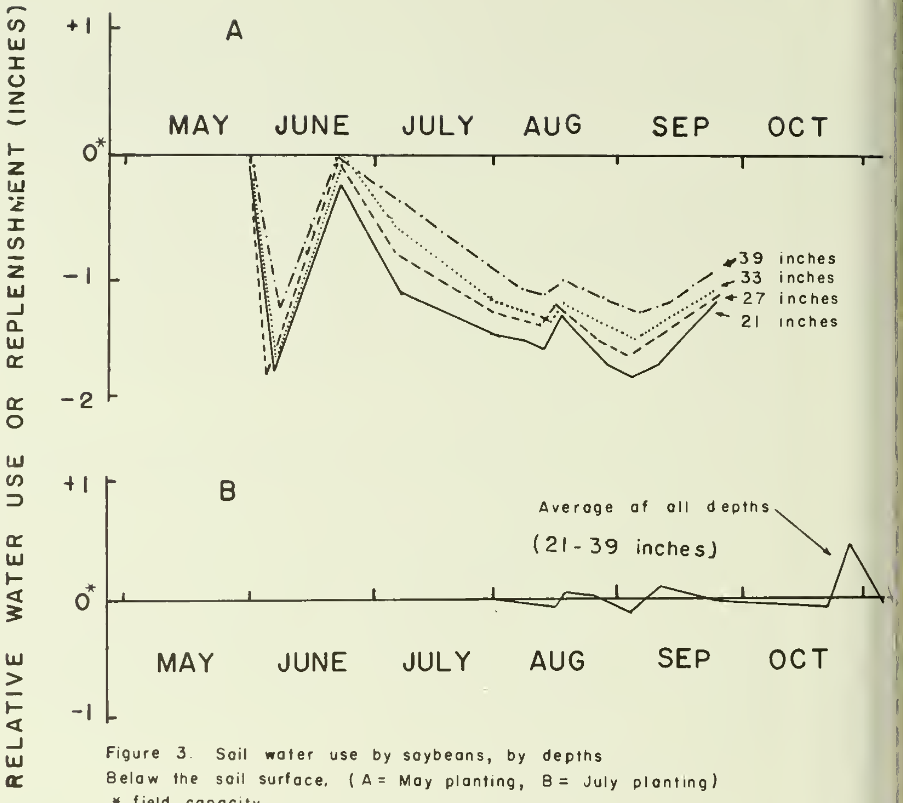

Figure 3. Soil water use by soybeans, by depths
Below the soil surface. (A = May planting, B = July planting)
* field capacity
Source: Data from the MAFES Black Belt Branch.

Table 5. Effect of planting date and variety on node numbers, b
planting date and variety, Verona,

Planting Date	Variety		
	Hill	Tracy	Bragg
	nodes/plant		
4-16-76	12.6	14.5	16.6
2-29-76	12.7	17.2	17.0
5-25-76	12.5	15.9	17.5
4-16-77	13.3	14.8	16.2
4-29-77	13.0	19.1	19.3
5-19-77	14.6	19.3	19.9
6-09-77	11.7	16.8	16.3

Table 6. Plant height at maturity, averages of all varieties tested a
Brooksville in 1976, by planting date and row width.

Planting Date	Row Width			
	7	30	40	Average
	inches			
4/20	31	27	28	28.7
4/30	35	28	28	30.3
5/20	32	27	25	28.0
6/14	29	22	25	25.3
7/02	23	18	17	19.3
7/15	12	13	15	13.3
Average	27.0	22.5	23.0	

t any of the upper four nodes on ie mainstem. Plant maturity was ecorded when some of the pods ecame mature pod colored.

Numbers of days from planting) flowering and numbers of days rom flowering to maturity for each f the five varieties at five planting ates in 1979 are presented in 'igure 4. This year was selected to epresent a year when there was elatively little crop stress. In ontrast, 1978 and 1980 were both ears in which a hot, dry period ccurred during much of the growng season. The data show that ays from planting to flowering are nfluenced strongly by planting ate. In the plots planted May 1, all arieties except Bragg flowered at he same time. The general trend or the later plantings was for the ater-maturing varieties to require nore days between planting and lowering than did the early arieties. Hill, however, usually equired a few more days to flower han did Forrest even though it matures earlier. This is a trait for which Hill has been noted previously; however, its fruiting period is shorter.

Numbers of days from flowering to maturity appear to be influenced strongly by planting date. However, in contrast to days to flower, the varietal effect seems to be greater at the early planting dates than at the late planting dates; i.e., at early planting dates there are several days difference among varieties in the length of time from flowering to maturity. Bragg required 80 days compared to about 50 days for Hill when planted on May 1. As the planting date was delayed, the difference in length of reproductive period among varieties was much less. Thus, in late plantings, the primary effect of varieties with later maturity is delayed flowering, not an extension of the pod-filling period.

Data collected in 1980 (a hot and dry growing season) show that length of time from planting to flowering was shorter in the hot season, and the varietal effect on days to flowering was less. Numbers of days from flowering to maturity, however, were longer. The later-maturing varieties (Tracy, Centennial and Bragg) required much longer from flowering to maturity at each planting date than did the earlier-maturing varieties (Hill, Forrest and Bedford). Thus, the hot weather appeared to shorten the time required to flower for all varieties tested but lengthened the period between flowering and maturity. Part of this lengthening probably was due to a delay in fertilization and the successful setting of pods. Due to the hot, dry weather in 1980, the early flowers were aborted, resulting in a long period during which additional flowers were produced. So, the time during which seed actually were being filled may not have been much different.

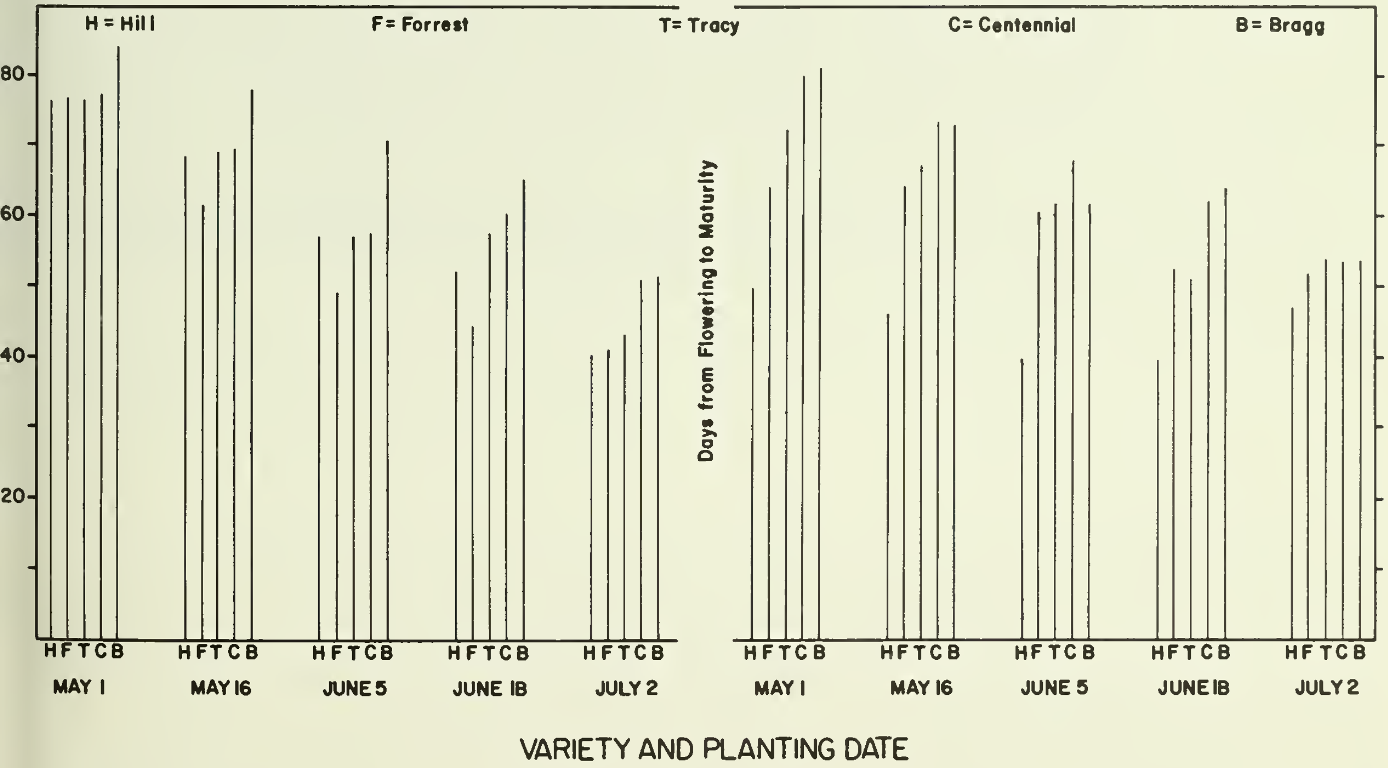

Figure 4. Time from planting to flowering and from flowering to maturity of soybeans grown on the MAFAS Plant Science Farm in 1979, by variety and planting date.

Table 7. Dates of soybean growth stage attainment, by variety and planting dates, Starkville, 1979[1].

	R-2	R-3	R-4	R-5	R-6	R-7	R-8
	date						
Hill							
PD 1[2]	7/16-7/26	7/26-7/29	7/29-8/4	8/04-8/8	8/08-8/26	8/26-9/05	9/05-9/08
2	7/17-7/28	7/28-8/4	8/04-8/9	8/9-8/21	8/21-8/28	8/28-9/06	9/06-9/09
3	8/02-8/7	8/07-8/13	8/13-8/19	8/19-8/29	8/29-9/6	9/06-9/09	9/09-9/15
4	8/11-8/17	8/17-8/23	8/23-8/27	8/27-9/3	9/03-9/12	9/12-9/16	9/16-9/21
5	8/12-8/14	8/14-8/31	8/31-9/3	9/03-9/9	9/09-9/21	9/21-9/26	9/26-10/02
Forrest							
PD 1	7/06-7/28	7/28-8/03	8/03-8/08	8/08-8/24	8/24-9/08	9/08-9/13	9/13-9/21
2	7/17-8/01	8/01-8/08	8/08-8/16	8/16-8/30	8/30-9/13	9/13-9/17	9/17-9/21
3	8/02-8/06	8/06-8/12	8/12-8/25	8/25-9/03	9/03-9/15	9/15-9/21	9/21-9/27
4	8/07-8/16	8/16-8/23	8/23-8/29	8/29-9/07	9/07-9/15	9/15-9/21	9/21-9/27
5	8/13-8/24	8/24-8/28	8/28-9/06	9/06-9/11	9/11-9/29	9/29-10/03	10/03-10/10
Tracy							
PD 1	7/06-8/04	8/04-8/12	8/12-8/23	8/23-8/30	8/30-9/21	9/21-9/24	9/24-10/01
2	7/17-8/09	8/09-8/13	8/13-8/25	8/25-9/03	9/03-9/21	9/21-9/24	9/24-10/03
3	8/08-8/12	8/12-8/19	8/19-8/27	8/27-9/04	9/04-9/24	9/24-9/28	9/28-10/03
4	8/08-8/20	8/20-8/27	8/27-9/02	9/02-9/09	9/09-9/26	9/26-10/01	10/01-10/06
5	8/14-8/22	8/22-8/28	8/28-9/07	9/07-9/19	9/19-9/30	9/30-10/03	10/03-10/08
Centennial							
PD 1	7/17-8/10	8/10-8/19	8/19-8/29	8/29-9/07	9/07-9/25	9/25-10/01	10/01-10/08
2	7/14-8/14	8/14-8/23	8/23-9/02	9/02-9/09	9/09-9/29	9/29-10/01	10/01-10/10
3	8/01-8/19	8/19-8/27	8/27-9/02	9/02-9/09	9/09-9/29	9/29-10/04	10/04-10/10
4	8/08-8/24	8/24-8/29	8/29-9/06	9/06-9/18	9/18-10/01	10/01-10/05	10/05-10/12
5	9/14-8/26	8/26-9/02	9/02-9/07	9/07-9/22	9/22-10/03	10/03-10/11	10/11-10/17
Bragg							
PD 1	7/21-8/15	8/15-8/18	8/18-8/26	8/26-9/08	9/08-10/01	10/01-10/09	10/09-10/17
2	7/24-8/15	8/15-8/18	8/18-8/30	8/30-9/11	9/11-10/01	10/01-10/10	10/10-10/18
3	8/08-8/17	8/17-8/24	8/24-9/01	9/01-9/11	9/11-10/01	10/01-10/10	10/10-10/20
4	8/14-8/24	8/24-8/29	8/29-9/06	9/06-9/19	9/19-10/07	10/07-10/10	10/10-10/20
5	8/22-8/27	8/27-9/02	9/02-9/06	9/06-9/19	9/19-10/07	10/07-10/13	10/13-10/22

[1] Growth stages from Fehr & Caviness, 1977.

[2] Planting Dates: PD 1 = May 1, PD 2 = May 16, PD 3 = June 5, PD 4 = June 18, PD 5 = July 2.

Table 7 contains data on the calendar time required for each variety at each planting date in the 1979 experiment to progress through the different reproductive growth stages (Table 8). This table can be used to estimate the length of time to maturity. It also may be used to compare the effect of planting date and variety on the rate of progression through the various reproductive growth stages. The growing season in 1979 was relatively cool and wet, especially during the reproductive period. By comparing the developmental rate of these soybean varieties with the same varieties in different years, some idea of the effect of weather on developmental rate can be gained.

Table 8. Reproductive stages of development of soybean

R1	time of first flower
R2	time when flowers are extended to any of the upper four nodes on the main stem
R3	beginning pod (3/16-inch long at any of the four uppermost nodes
R4	full pod (3/4-inch long or longer at any of the four uppermost nodes)
R5	beginning seed (slight seed enlargement can be felt)
R6	full seed (pod containing green seed that fill the cavity of pod at any of the top four nodes)
R7	beginning maturity (leaves turning yellow and one pod on mainste has reached mature pod color)
R8	full maturity (95% of pods have reached mature pod color)

Five to 10 days of drying weather are required before R8 beans have les than 15% moisture.

Source: Fehr and Caviness, 1977.

Discussion

ate of Planting

Results of this trial are similar to iose from trials in other states. he response to planting dates by dapted varieties was compared to linois, Kentucky, South Carolina nd Florida. Varieties best adapted) each location were tested at everal planting dates. The yield esponse to planting dates was imilar at each location.

Examination of our results on the effect of date of planting on soybean yields (Figure 2, Table 1 and Appendix Tables 1-6) reveals marked declines in yields of soybeans planted after June 10. Comparison of these data with the historic planting practices of Mississippi producers (Figure 1) shows that 33% of the Mississippi soybean acreage is planted too late for optimum production. Producers need to find ways to plant more acreage during the optimum planting period (May 1 to June 10). The data (Table 1) show that soybeans planted in northern Mississippi as early as April 15-20 yield more than those planted after June 10.

ow Spacing

Soybeans grown in 7-inch rows ver the soil surface more quickly id should reduce erosion, but iere are some reasons for using iis production practice with ution. Generally it is more dif- cult to get uniform seed place- ent (in-the-row and depth) with a ain drill than with a row planter. 'e had some poor stands from lanting with a grain drill where lanting conditions were marginal ut did get acceptable stands with w-planting equipment. Grain- rills, however, are being improved r better depth control and place- ent in the row. Because of the reater risk in stand establishment ith old types of grain drills, more eed/acre may need to be planted ith a grain drill than when lanting in rows.

The reasons for differences in sults of row-spacing research in idwestern states and results from our study and from studies at several other locations---e.g., south Georgia and South Carolina (Parker and Marchant, 1981 and Palmer, 1980)---are not completely understood. Midwestern research reports 5-15% increases in yields of soybeans planted in narrow rows (20 inches or less) over yields with 30-inch and wider row spacings.

This difference in response may be caused by combinations of soils and weather that prevail in the southern states. The high temperatures in the southern states cause high rates of water use, and this, in association with frequent short-period droughts, exposes crops to short periods of drought stress. The soils on which soybeans are produced in Mississippi are often fine textured and have low hydraulic conductivity that results in slower water movement than in the midwestern coarser textured soils or fine textured soils with more organic matter and a more developed soil structure. Thus, a uniform distribution of soybean plants over the soils used in this study may result in a more rapid use of available water early in the season and reduce the availability of stored water later in the season. Unless an excellent distribution of rain occurs during the growing season (especially July, August and September), the narrow-rows (drilled crop) are exposed to more serious drought stress than are crops planted on 30-inch row spacings. Also, stands in some of our late-planted plots were poor, especially the drill-seeded plots, which may be the reason for failure to obtain a higher yield in late, drill-seeded beans than in beans planted on the 30- and 40-inch rows.

'lowering

The variety determines how ort days have to be before flower- g is induced. Young seedlings owing under conditions that do ot induce flowering normally ave five to eight immature leaf ıds and vegetative nodes in the owing tip of the stem. An ad- tional immature leaf is formed as e oldest buds grow and become sible. The next immature node becomes floral rather than vegetative when the photoperiod becomes short enough for leaves to induce flowering, and the plant will begin to flower when that developing bud matures. The plant then ceases to grow additional main-stem nodes.

Some stem elongation and branch growth may occur after the apex becomes floral. First flowering usually is apparent near the middle of the main stem, and flowers seemingly develop at random at nodes on the main stem. Flowering on the branches occurs in much the same pattern but a few days later than on the main stem.

Late-planted beans often are induced to flower when the first true leaf is exposed, and this causes the newly formed buds in the tip of the stem to be floral. As soon as the five to eight preformed leaf buds have developed, this floral bud will be the next to mature and the plant begins to flower. This usually is long before the "vegetative factory" is large enough to supply adequate photosynthetic materials for optimum seed production. Such small plants can be expected to yield less per plant; therefore, higher yields from late-planted beans can be expected if narrower plant spacings are used. However, this is not always evident due to other growth limiting factors.

In general, the late-maturing varieties are less sensitive to photoperiod than are early- or mid-season varieties. Results from south Georgia showed the most nodes/plant from early May planting and the fewest from early July planting. Bragg and Hutton had 12 and 13 nodes, respectively, when planted in early July compared with the earlier maturing Essex which had only 10 nodes. Beans planted in early April had two to three fewer nodes than those planted in early May but one t three more nodes than thos planted in early July. Centennia planted in mid-June at Starkvill Mississippi, produced 20 nodes o plants 39 inches tall but, whe planted in late July, averaged onl 9.5 nodes/plant and 8.6 inches tal

Flower racemes originate fron buds at the nodes. The more nodes the more chances for racemes whe the days become short enough t stimulate flower formation.

Root Development

The above-ground and below-ground plant parts grow normally during vegetative development. Roots may grow 5 to 8 ft deep under good soil conditions, but there generally are not enough very deep roots to supply all the water needed to the developing leaves.

Many small secondary and tertiary roots live for only a short time, and they die faster if conditions become less favorable. Their replenishment depends on a ready supply of organic nutrients in the form of sugars supplied by the leaves. Thus, if above-ground conditions become unfavorable for growth or other plant parts become too competitive for available sugars, roots die faster than replacement roots are developed.

Developing seed become a repository for large quantities of the sugars produced by leaves. About two weeks normally are required from flowering until the developing seed begin to add significant dry weight, after which the seed grow rapidly and, apparently because of their proximity to the leaves, receive the major part of the sugars available from the leaves. Therefore, during the period of maximum seed growth (from about two weeks after flowering until maturity), root numbers decrease and total root length decreases. This causes the plant to become more dependent on fewer roots for its water and nutrient supply.

This occurs in Mississippi during August and September for early varieties and during late August, September and October for late varieties. The plants are most susceptible to drought during this time. This also is a period of very high evaporative demand. The combination of intra-plant competition for nutrients, which results in a decreasing root mass, and the high evaporative demand of the atmosphere forces the crop into a highly dependent situation relative to available water supply. The crop needs a soil with excellent water-holding capabililties and a reasonable seasonal distribution of rain if it is to reach its yield potential.

In late-planted beans, which flower while the plant is still small, the intra-plant competition for available nutrients limits root development. In such cases, the smaller root mass forces the plant into a less competitive position relative to removal of available soil water than exists for plants that have had adequate time for vegetative growth and root development before flowering. Such late-planted beans are more dependent on a uniform distribution of rainfall during the growing season.

The failure of July-planted beans to root deeply in Mississipp probably is caused by the interna competition of one plant part wit another for available carbohydrates. The late-planted bean are induced to flower before the have a chance to develop a larg root system, and a major part of th available carbohydrates is used i seed production rather than fo leaf, stem and root growth.

Premature flowering results in self-destructive situation for th plant in a dry environment becaus the plant is unable to feed the roo to support the growth it need Thus, the late-planted crop is muc more dependent on timely rainfa than is the crop planted at th optimum time.

Data on growth-stages were no collected on the experiments i south Mississippi during th relatively cool and wet growin season in 1979. Similar data we collected for the varieties Esse Davis, Bragg and Hutton at Tifto Georgia. A three-year average the planting date, flowering an maturity-date data shows that th length of time to flowering considerably shorter at th latitude than at Starkville. Brag required 82 and 52 days fro planting to flowering at Starkvil when planted in early May an early July, respectively. In sou Georgia, Bragg required only and 40 days to develop flowers aft anting in early May and early ly, respectively. In south eorgia, the day length will be orter in summer than in north ississippi. Therefore, it appears at the critical short-day length ecessary to induce flowering in ragg occurs 12 to 20 calendar ays earlier at Tifton, Georgia than t Starkville, Mississippi.

The length of time from flowering to maturity for soybeans at the more southernly latitude was longer than that at Starkville. Bragg required 108 days from flowering to maturity in south Georgia when planted in early May but only 81 days at Starkville. When planted in early July, the length of Bragg's reproductive period was reduced to 68 days at the more southernly latitude and 55 days at Starkville. The effect of relatively small changes in day length (as influenced by north-south location and planting dates) obviously can have a large effect on the development of soybeans.

Cultural Considerations

Two very serious constraints on te planting are difficulty in btaining stands and water-related roblems.

Row-planted beans can be ltivated and herbicides can be ost-directed for weed control; hereas, weed control in drill-lanted beans must be acomplished entirely with over-the-top herbicides and canopy cover. Cultivation and post-directed herbicide applications for weed control are generally less costly than broadcast over-the-top herbicide applications. Beans on rows may be treated with herbicides over-the-top, in a band over the row or post-directed; however, only over-the-top applications can be used with solid-seeded beans.

Late-season insect populations frequently are such a serious threat to soybeans in south Mississippi that producers need to be alert to damaging infestations each season and be prepared to apply insecticides as needed.

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Appendix Table 1. Yield of soybeans, by planting date, variety and row spacing, MAFES North Mississippi Branch, 1976-79.

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		1976			
		------------ bushels/acre[1/] ------------			
4/16	Kent	20.4 c	27.4 d	26.2 c	24.2
	Hill	46.2 ab	38.0 b	44.0 a	42.7
	Forrest	38.5 b	40.2 b	37.2 b	38.6
	Tracy	49.3 a	50.3 a	48.7 a	49.1
	Lee 74	40.4 ab	36.5 b	38.3 b	38.4
	Bragg	29.3 c	28.8 d	27.7 c	28.6
	Average	37.3	36.9	37.0	37.1
4/29	Kent	25.7 d	34.1 bc	36.5 ab	32.1
	Hill	36.4 b	34.7 bc	34.2 ab	35.1
	Forrest	42.4 a	35.2 bc	40.9 a	39.5
	Tracy	43.4 a	43.4 a	40.5 a	42.4
	Lee 74	33.1 c	41.2 ab	34.2 ab	36.2
	Bragg	17.0 e	31.0 c	29.0 b	25.7
	Average	33.0	36.6	35.9	35.2
5/25	Kent	34.5 ab	31.1 b	36.4 b	34.0
	Hill	38.0 ab	42.0 a	45.3 a	41.8
	Forrest	35.6 ab	43.7 a	42.2 ab	40.5
	Tracy	40.4 a	44.2 a	46.2 a	43.6
	Lee 74	32.2 b	44.4 a	40.4 ab	39.0
	Bragg	31.6 b	33.9 b	34.7 b	33.4
	Average	35.4	39.9	40.9	38.7
6/30	Kent	21.4 b	25.2 a	21.8 a	22.8
	Hill	28.1 a	28.9 a	25.0 a	27.3
	Forrest	28.4 a	28.9 a	22.7 a	26.7
	Tracy	27.9 a	29.3 a	24.2 a	27.1
	Lee 74	27.0 a	27.5 a	26.8 a	27.1
	Bragg	27.3 a	29.5 a	27.6 a	28.1
	Average	26.7	28.2	24.7	26.5

continued

Appendix Table 1. (Continued)

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		1977			
		---------------bushels/acre-----------------			
4/16	Hill	21.6 by	25.9 cx	26.4 b x	24.6
	Forrest	36.8 a xy	40.6 a x	32.6 a y	36.7
	Tracy	33.3 a x	37.7 ab x	35.7 a x	35.6
	Centennial	31.9 a x	36.0 b x	34.2 a x	34.0
	Bragg	12.6 c z	18.2 d y	20.4 c x	17.1
	Average	27.2	31.7	30.0	29.6
4/30	Hill	26.1 b y	34.1 b x	30.5 b x	30.2
	Forrest	41.9 a x	46.4 a x	41.8 a x	43.4
	Tracy	42.7 a x	43.9 a x	39.3 a x	42.0
	Centennial	38.9 a y	44.5 a x	40.4 a y	41.3
	Bragg	11.0 c y	20.4 c x	18.4 c x	16.6
	Average	32.1	37.9	34.1	34.7
5/19	Hill	36.7 b x	33.4 b x	31.7 c x	33.9
	Forrest	52.4 a x	37.9 a y	37.5 a y	42.6
	Tracy	38.1 b x	37.9 a x	33.1 bc x	36.4
	Centennial	35.5 b x	37.9 a x	36.4 ab x	36.6
	Bragg	9.4 c y	15.1 c x	14.9 d x	13.1
	Average	34.4	32.4	30.7	32.5
6/09	Hill	31.7 b xy	36.5 a x	31.0 a y	33.1
	Forrest	37.8 a x	33.8 ab x	34.1 a x	35.2
	Tracy	32.7 ab x	37.4 a x	31.6 a x	33.9
	Centennial	33.1 ab x	33.9 ab x	31.7 a x	32.9
	Bragg	14.8 c y	27.8 b x	19.9 b y	20.8
	Average	30.0	33.9	29.7	31.2
7/06	Hill	22.2 ab x	18.9 c x	16.5 c x	19.2
	Forrest	28.2 a x	27.7 a x	22.0 abc x	26.0
	Tracy	25.2 ab x	20.1 bc x	23.1 ab x	22.8
	Centennial	24.7 ab x	26.2 ab x	26.9 a x	25.9
	Bragg	20.0 b x	16.8 c x	17.2 bc x	18.0
	Average	24.1	21.9	21.1	22.4

continued

Appendix Table 1. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	30	40	Average
		1978			
		bushels/acre			
4/17 [2]	Hill	27.8	29.0	23.7	26.8
	Forrest	26.8 bc x	31.4 a x	29.8 bc x	29.3
	Tracy	34.8 a x	37.6 a x	37.3 a x	36.6
	Centennial	33.0 ab x	30.2 a x	33.5 ab x	32.2
	Bragg	22.7 c x	24.8 a x	27.2 c x	24.9
	Average	29.4	31.0	31.9	30.8
5/19	Hill	[3] --	27.8	24.4	26.1
	Forrest	35.8 a x	30.7 a x	30.6 b x	32.4
	Tracy	39.2 a x	33.8 a x	38.1 a x	37.0
	Centennial	40.9 a x	36.4 a x	38.7 a x	38.7
	Bragg	28.1 b x	29.3 a x	30.6 b x	29.3
	Average	36.0	32.5	34.5	34.3
6/6	Hill	30.0	[3] --	[3] --	[3] --
	Forrest	39.4 b y	45.3 a x	42.5 ab xy	42.4
	Tracy	40.0 b y	47.7 a x	41.2 ab y	43.0
	Centennial	45.6 a x	48.9 a x	45.9 a x	46.8
	Bragg	36.0 b y	47.8 a x	37.4 b y	40.4
	Average	40.2	47.4	41.8	43.2
6/28	Hill	29.2	25.6	22.5	25.8
	Forrest	39.6 a x	37.1 a x	34.6 a x	37.1
	Tracy	38.4 a x	33.0 a y	33.0 a y	34.8
	Centennial	40.2 a x	37.4 a x	33.1 a y	36.9
	Bragg	35.8 a x	37.8 a x	32.8 a x	35.5
	Average	38.5	36.3	33.4	36.1
		1979			
4/20	Hill	22.9 bx	26.3 bx	26.2 bx	25.2
	Forrest	5.8 cy	14.6 cx	13.5 cx	11.3
	Tracy	41.4 ax	38.4 ax	41.5 ax	40.4
	Centennial	18.5 by	30.1 abx	25.6 bxy	24.7
	Bragg	0.8 cx	1.2 cx	1.4 cx	1.1
	Average	17.4	22.1	21.1	

continued

Appendix Table 1. (Continued)

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		bushels/acre			
5/21	Hill	25.4 bcy	26.9 bcy	23.4 by	25.2
	Forrest	22.4 cy	23.8 cy	22.6 by	22.9
	Tracy	34.0 ay	37.5 ax	32.6 ay	34.7
	Centennial	28.8 aby	31.5 by	30.5 ay	30.3
	Bragg	12.9 dy	17.8 dxy	21.4 bx	17.4
	Average	24.7	27.5	26.1	
6/13	Hill	33.2 ax	34.1 bx	26.0 ax	31.1
	Forrest	37.8 ax	35.8 bxy	27.4 ay	33.7
	Tracy	39.8 ax	35.4 bx	29.2 ay	34.8
	Centennial	40.2 ax	39.3 ax	32.6 ax	37.4
	Bragg	35.4 ax	28.6 cx	27.2 ax	30.4
	Average	37.3	34.6	28.5	
6/29	Hill	31.3 ax	23.8 bxy	18.9 abcy	24.6
	Forrest	25.6 ax	22.1 bxy	14.3 cy	20.7
	Tracy	27.2 ax	25.9 abx	16.9 cy	23.3
	Centennial	36.0 ax	33.5 ax	26.8 ax	32.1
	Bragg	33.5 ax	25.1 aby	24.0 aby	27.5
	Average	30.7	26.1	20.2	

*Adjusted to 13% moisture.

[1] Within each row width and planting date, values followed by the same letter (a, b, c or d) are not different at a probability of equal to or less than 0.05 as determined by Duncan's New Multiple Range Test. Values across row width, within a date and within a variety are not different if followed by the same letter (x or y).

[2] Hill seed was of poor quality and, although planting rate was increased, the resulting yield may be artificially low. Hill was therefore excluded from data analysis.

[3] Was not harvested because of poor stand.

end of table.

Appendix Table 2. Yield of soybeans, by planting date, variety and row spacing, MAFES Plant Science Farm, 1976-79.

		Yield* Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		1976			
		bushels/acre			
4/16	Kent	14.6 c[1]	8.9 c	9.2 c	10.9
	Hill	33.0 b	24.1 b	19.6 b	25.6
	Forrest	36.5 ab	21.4 b	17.0 bc	25.0
	Tracy	53.7 a	42.2 a	39.8 a	45.2
	Lee 74	45.7 ab	31.4 ab	36.1 a	37.7
	Bragg	46.6 ab	33.0 ab	35.4 a	38.3
	Average	38.3	26.8	26.1	
4/28	Kent	11.4 c	14.6 b	15.8 c	13.9
	Hill	28.0 b	33.8 a	25.2 bc	29.0
	Forrest	28.2 b	38.3 a	25.9 b	30.8
	Tracy	38.9 a	46.8 a	34.6 ab	40.1
	Lee 74	45.1 a	43.2 a	39.7 a	42.7
	Bragg	40.6 a	43.8 a	40.6 a	41.7
	Average	32.0	36.7	30.3	
5/24	Kent	34.9 c	28.1 b	22.7 c	28.6
	Hill	46.4 b	35.0 b	33.3 b	38.2
	Forrest	53.6 a	52.3 a	44.6 a	50.2
	Tracy	45.3 b	46.0 a	42.0 a	44.4
	Centennial	40.2 bc	48.5 a	42.8 a	43.8
	Bragg	44.3 b	44.6 a	44.1 a	44.3
	Average	44.1	42.4	38.2	
6/8	Kent	10.7 c	13.1 d	18.0 c	13.9
	Hill	31.4 b	27.4 c	25.2 bc	28.0
	Forrest	37.3 ab	27.9 c	27.4 ab	30.9
	Tracy	36.3 ab	32.9 b	30.2 ab	33.1
	Centennial	40.9 a	38.8 a	35.6 a	38.4
	Bragg	42.8 a	35.4 ab	32.4 ab	36.9
	Average	33.2	29.2	28.1	

continued

Appendix Table 2. (Continued)

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		bushels/acre			
7/12	Kent	late maturity and fall rains prevented harvest			
	Hill				
	Forrest				
	Tracy				
	Centennial				
	Bragg				
		1977			
		bushels/acre			
4/14	Hill	14.5 b y	22.8 c x	22.3 bc x	19.9
	Forrest	14.5 b y	26.1 bc x	20.6 c xy	20.4
	Tracy	22.6 ab y	35.9 a x	31.8 a xy	30.1
	Centennial	27.2 a x	34.5 a x	28.6 ab x	30.1
	Bragg	24.4 ab y	28.3 b xy	29.0 ab x	27.2
	Average	20.6	29.5	26.5	25.5
5/2	Hill	26.9 a x	27.8 b x	21.2 a x	25.3
	Forrest	30.0 a x	26.6 b x	22.8 a x	26.5
	Tracy	36.1 a x	38.8 a x	30.4 a x	35.1
	Centennial	36.5 a x	33.9 ab x	31.7 a x	34.0
	Bragg	30.9 a x	27.7 b y	25.2 a z	27.9
	Average	32.1	31.0	26.3	30.0
5/16	Hill[2/]	12.6 a y	27.1 a x	16.5 b y	18.7
	Forrest[2/]	11.4 a y	29.0 a x	20.1 ab xy	20.2
	Tracy[2/]	13.2 a y	34.0 a x	29.1 a x	25.4
	Centennial[2/]	16.4 a y	31.5 a x	22.4 ab xy	23.4
	Bragg[2/]	11.5 a y	26.8 a x	19.5 ab x	19.3
	Average	13.0	29.7	21.5	21.4
5/30	Hill	23.2 b x	22.4 bc x	13.9 c y	19.8
	Forrest	30.0 a x	28.0 ab x	22.8 ab x	26.9
	Tracy	34.0 a x	30.1 a x	28.5 a x	30.9
	Centennial	28.8 ab x	27.1 ab x	21.8 b y	25.9
	Bragg	22.6 b x	21.0 c x	19.8 bc x	21.1
	Average	27.7	25.7	21.4	24.9

continued

Appendix Table 2. (Continued)

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		--------------bushels/acre------------------			
6/15	Hill	11.5 a x	14.6 a x	15.0 a x	13.7
	Forrest	14.3 a x	16.7 a x	14.1 ab x	15.0
	Tracy	10.9 a x	11.1 a x	11.1 ab x	11.0
	Centennial	10.3 a x	14.0 a x	10.6 ab x	11.6
	Bragg	9.0 a x	11.1 a x	7.5 b x	9.2
	Average	11.2	11.3	11.6	12.1
7/6	Plots not harvested due to very poor stands caused by intense rainfall July 9.				
		1978			
4/15	Hill[3/]	16.0	20.4	18.9	18.4
	Forrest	19.2 c x	24.4 b x	24.2 b x	22.6
	Tracy	22.8 bc x	26.2 b x	27.2 ab x	25.4
	Centennial	32.7 a x	38.0 a x	33.7 a x	34.8
	Bragg	28.7 ab x	29.0 b x	28.4 ab x	28.7
	Average	25.8	29.4	28.4	27.9
4/28	Hill	21.3	15.8	12.5	16.5
	Forrest	27.6 b x	24.1 b x	19.0 b x	23.6
	Tracy	40.7 a x	35.3 a x	34.7 a x	36.9
	Centennial	37.2 a x	41.0 a x	32.4 a x	36.9
	Bragg	36.7 a x	35.1 a xy	30.4 a y	34.1
	Average	35.5	33.8	29.1	32.8
5/17	Hill	22.0	22.3	20.2	21.5
	Forrest	31.9 c x	26.7 b x	18.7 b y	25.8
	Tracy	42.5 ab x	42.4 a x	39.1 a x	41.3
	Centennial	47.8 a x	40.9 a y	37.9 a y	42.2
	Bragg	38.2 b x	36.6 a x	35.6 a x	36.6
	Average	40.1	36.6	32.7	36.5
6/5	Hill	13.3	15.8	17.4	15.5
	Forrest	17.4 c y	28.3 a x	18.6 a y	21.4
	Tracy	27.6 b x	33.6 a x	26.6 a x	29.3
	Centennial	31.2 ab xy	36.6 a x	25.6 a y	31.1
	Bragg	38.4 a x	28.8 a y	25.3 a y	30.8
	Average	28.6	31.8	24.0	28.2

continued

Appendix Table 2. (Continued)

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		--------------bushels/acre			----------------
6/30	Hill	4/ --	4/ --	4/ --	4/ --
	Forrest	2.8 a x	5.5 a x	4.4 a x	4.2
	Tracy	3.9 a x	7.8 a x	4.7 a x	5.5
	Centennial	4.8 a x	6.9 a x	5.6 a x	5.8
	Bragg	4.0 a x	6.7 a x	6.6 a x	5.8
	Average	3.9	6.7	5.3	5.3
		1979			
5/1	Hill	28.5 cx	28.0 ax	23.6 cx	26.7
	Forrest	35.1 bcx	41.6 ax	28.9 bcx	35.2
	Tracy	45.8 ax	41.1 axy	37.5 ay	41.5
	Centennial	43.8 ax	40.8 ax	34.0 aby	39.5
	Bragg	39.1 abx	34.9 ax	33.1 abx	35.7
	Average	38.5	37.3	31.4	
5/16	Hill	27.4 cx	31.8 cx	26.3 cx	28.5
	Forrest	34.3 bcxy	39.6 ax	30.5 bcy	34.8
	Tracy	42.3 abx	41.8 ax	37.6 ax	40.6
	Centennial	46.9 ax	38.8 aby	35.0 aby	40.2
	Bragg	32.6 bcx	35.6 bcx	34.2 abx	34.1
	Average	36.7	37.5	32.7	
6/5	Hill	34.8 bx	34.8 bcx	29.1 cy	32.9
	Forrest	37.8 abx	37.1 bxy	33.8 by	36.2
	Tracy	43.4 ax	42.0 axy	38.5 ay	41.3
	Centennial	43.6 ax	42.8 ax	33.2 by	39.9
	Bragg	29.1 abz	31.9 cy	36.2 abx	32.4
	Average	37.7	37.7	34.2	
6/18	Hill	23.0 bx	18.0 bx	14.5 bx	18.5
	Forrest	34.4 ax	23.3 by	16.0 bz	24.2
	Tracy	41.6 ax	30.7 ay	17.9 bz	30.1
	Centennial	38.7 ax	32.4 axy	27.0 ay	32.7
	Bragg	32.7 ax	22.2 by	17.7 by	24.2
	Average	33.9	25.3	18.6	

continued

Appendix Table 2. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	30	40	Average
		---------------bushels/acre---------------			
7/2	Hill	20.7 bx	19.7 cx	17.0 ax	19.1
	Forrest	21.7 bx	22.6 bcx	22.7 ax	22.3
	Tracy	27.0 abx	27.9 ax	21.1 ax	25.3
	Centennial	31.4 ax	29.7 ax	24.3 ay	28.5
	Bragg	28.7 abx	26.1 abx	24.0 ax	26.3
	Average	25.9	25.2	21.8	

end of table

*Adjusted to 13% moisture.

[1] Within each row width and planting date, values followed by the same letter (a, b, or c) are not different ($1^{o} <.05$) of equal to or less than 0.05 as determined by Duncan's New Multiple Range Test. Values across row widths within a date and within a variety are not different if followed by the same letter (x, y, or z).

[2] Poor stands were obtained in soybeans planted 5/16 due to dry weather. This was especially a problem with those plots planted on 7-inch rows.

[3] Hill seed was of poor quality and, although planting rate was increased, the resulting yield may be artificially low. Hill was therefore excluded in data analysis.

[4] Was not harvested because of poor stand.

Appendix Table 3. Yield of soybeans, by planting date, variety and row spacing, MAFES Black Belt Branch, 1976-79.

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		1976			
		bushels/acre			
4/20	Kent	19.8 c[1/]	16.4 e	13.3 c	16.5
	Hill	26.6 b	25.6 cd	24.5 b	25.6
	Forrest	34.2 a	22.9 d	22.8 b	26.6
	Tracy	38.6 a	36.2 a	31.6 a	35.5
	Lee 74	36.8 a	32.6 ab	24.0 b	31.1
	Bragg	31.9 ab	29.0 bc	20.7 b	27.2
	Average	31.3	27.1	22.8	
4/30	Kent	24.8 b	15.2 c	13.1 c	17.7
	Hill	25.2 b	22.2 b	21.0 b	22.8
	Forrest	34.3 a	24.2 b	24.3 ab	27.6
	Tracy	33.4 a	33.2 a	28.0 a	31.5
	Lee 74	34.4 a	28.0 a	23.6 ab	28.7
	Bragg	31.2 a	23.6 b	21.0 b	25.3
	Average	30.6	24.4	21.8	
5/20	Kent	28.2 c	20.5 b	13.9 b	20.9
	Hill	32.5 bc	26.4 ab	23.0 a	27.3
	Forrest	35.5 ab	37.1 a	20.8 ab	31.1
	Tracy	35.2 ab	36.4 a	28.6 a	33.4
	Lee 74	39.4 a	37.5 a	26.6 a	34.5
	Bragg	35.4 ab	33.8 a	26.5 a	31.9
	Average	34.4	32.0	23.2	
6/14	Kent	27.2 b	26.9 a	16.2 b	23.4
	Hill	36.6 a	30.2 a	30.2 a	32.3
	Forrest	39.0 a	27.7 a	29.3 a	32.0
	Tracy	37.5 a	32.5 a	30.4 a	33.5
	Lee 74	38.2 a	35.6 a	32.9 a	35.6
	Bragg	37.2 a	33.8 a	34.2 a	35.1
	Average	35.9	31.1	28.9	

continued

Appendix Table 3. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	30	40	Average
		--------bushels/acre--------			
7/02	Kent	17.6 b	12.7 cd	12.0 ab	14.1
	Hill	22.4 ab	19.4 ab	12.9 ab	18.2
	Forrest	22.1 ab	12.2 d	11.6 b	15.3
	Tracy	20.6 b	16.4 bcd	12.6 ab	16.5
	Lee 74	27.4 a	18.7 abc	14.3 ab	20.1
	Bragg	27.5 a	23.7 a	16.2 a	22.5
	Average	22.9	17.2	13.3	
7/15	Kent				
	Hill				
	Forrest	Late maturity and fall rains prevented harvest			
	Tracy				
	Lee 74				
	Bragg				
		1977			
4/14	Hill	7.1 b xy	10.9 b x	5.4 b y	7.8
	Forrest	10.6 b x	12.4 b x	9.5 b x	10.8
	Tracy	16.8 a xy	19.3 a x	16.0 a y	17.4
	Centennial	18.0 a x	18.7 a x	17.8 a x	18.2
	Bragg	15.1 a x	18.0 a x	15.9 a x	16.3
	Average	13.5	15.9	12.9	14.1
4/28	Hill	9.2 b x	9.3 b x	7.4 b x	8.6
	Forrest	12.4 b x	12.6 b x	8.3 b y	11.1
	Tracy	18.6 a x	19.9 a x	15.1 a y	17.9
	Centennial	18.5 a x	19.1 a x	16.7 a x	18.1
	Bragg	16.2 a x	18.3 a x	15.2 a x	16.6
	Average	15.0	15.8	12.5	14.5
5/13	Hill	8.7 c x	6.9 b xy	5.7 b y	7.1
	Forrest	10.8 bc x	8.9 b xy	8.2 b y	9.3
	Tracy	14.1 b x	17.8 a x	14.0 a x	15.3
	Centennial	17.7 a x	16.3 a x	16.9 a x	17.0
	Bragg	12.9 b y	17.4 a x	15.5 a xy	15.3
	Average	12.8	13.5	12.1	12.8

continued

Appendix Table 3. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	30	40	Average
		bushels/acre			
6/15	Hill	4.3 a x	2.6 a x	3.0 a x	3.3
	Forrest	4.2 a x	6.2 a x	4.5 a x	5.0
	Tracy	4.1 a x	4.8 a x	3.6 a x	4.2
	Centennial	7.2 a x	5.2 a x	4.7 a x	5.7
	Bragg	5.9 a x	4.3 a x	4.9 a x	5.0
	Average	5.2	4.6	4.1	4.6
6/30	Hill	1.6 b x	1.8 a x	0.8 c x	1.4
	Forrest	1.5 b x	2.8 a x	2.5 ab x	2.3
	Tracy	4.5 a x	1.6 a y	1.4 bc y	2.5
	Centennial	1.9 b x	2.4 a x	3.8 a x	2.7
	Bragg	2.4 b x	2.7 a x	2.3 bc x	2.5
	Average	2.8	2.7	2.0	2.5
		1978			
4/17	Hill[2/]	16.0	11.0	10.2	12.4
	Forrest	15.6 a x	14.4 a x	14.1 a x	14.7
	Tracy	8.9 b x	12.6 ab x	9.8 b x	10.4
	Centennial	6.2 b x	4.8 c x	8.4 b x	6.5
	Bragg	6.0 b y	8.3 bc x	9.3 b x	7.9
	Average	9.2	10.0	10.4	9.9
5/15	Hill	16.6	17.5	15.8	16.6
	Forrest	17.8 a x	18.6 a x	18.1 a x	18.2
	Tracy	13.7 ab x	18.6 a x	18.3 a x	16.9
	Centennial	7.8 c x	7.6 b x	13.0 a x	9.5
	Bragg	10.2 bc x	14.9 a x	15.9 a x	13.7
	Average	12.4	14.9	16.3	14.5
6/1	Hill	15.3	18.6	14.7	16.2
	Forrest	17.1 a y	25.8 a x	17.2 b y	20.0
	Tracy	23.4 a x	25.5 a x	22.5 a x	23.8
	Centennial	19.4 a x	21.6 a x	17.2 b x	19.4
	Bragg	20.5 a x	20.7 a x	17.8 ab x	19.7
	Average	20.1	23.4	18.7	20.7

continued

Appendix Table 3. (Continued)

Planting Date	Variety	Yield*			
		Row Width (inches)			
		7	30	40	Average
		------------bushels/acre------------			
6/15	Hill	3.6	5.4	6.0	5.0
	Forrest	18.4 a x	18.2 a x	16.5 a x	17.7
	Tracy	19.9 a x	21.0 a x	20.0 a x	20.3
	Centennial	16.4 a y	19.4 a x	18.2 ab xy	18.0
	Bragg	15.7 a x	22.0 a x	20.2 a x	19.3
	Average	17.6	20.1	18.7	18.8
6/30	Hill	--3/	--	--	--
	Forrest	1.1 b y	3.2 a y	6.1 a x	3.5
	Tracy	4.3 a x	4.8 a x	5.6 a x	4.9
	Centennial	0.7 by	3.6 a xy	5.7 a x	3.3
	Bragg	2.1 ab y	3.5 a x	6.5 a x	4.0
	Average	2.0	3.8	6.0	3.9
7/14	Hill	--	--	--	--
	Forrest	9.6 a x	3.4 a y	0.7 c y	4.6
	Tracy	5.3 a x	4.3 a x	1.7 ab y	3.7
	Centennial	7.2 a x	6.3 a x	2.3 a x	5.4
	Bragg	5.1 a x	4.6 a x	1.4 b x	3.7
	Average	6.8	4.6	1.6	4.3
		1979			
4/18	Hill	13.9 bx	12.2 bx	12.6 bx	12.9
	Forrest	14.5 bx	13.0 bx	9.0 bx	12.1
	Tracy	17.8 abx	17.2 bx	14.1 bx	16.3
	Centennial	24.9 ax	23.7 ax	22.1 ax	23.6
	Bragg	16.9 bx	15.6 bx	15.3 bx	15.9
	Average	17.6	16.4	14.6	
4/30	Hill	19.0 ax	15.7 ax	13.3 bx	16.0
	Forrest	23.9 ax	17.1 ax	12.0 bx	17.7
	Tracy	34.1 ax	25.2 ax	20.5 abx	26.6
	Centennial	33.7 ax	22.8 ax	25.6 ax	27.4
	Bragg	28.7 ax	20.9 ax	16.5 abx	22.0
	Average	27.9	20.3	17.6	

continued

Appendix Table 3. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	30	40	Average
		------------bushels/acre	---------------	---------------	---------------
5/17	Hill	9.7 by	21.3 cdx	14.4 bxy	15.1
	Forrest	19.2 ax	13.7 dx	15.5 bx	16.8
	Tracy	23.9 ax	29.3 abx	26.5 ax	26.6
	Centennial	25.6 az	34.5 ax	30.0 ay	30.0
	Bragg	23.8 ax	24.2 bcx	25.4 ax	24.5
	Average	20.5	25.0	22.4	
6/5	Hill	15.3 bx	19.0 abx	18.7 ax	17.7
	Forrest	11.7 bx	17.0 bx	15.5 ax	14.8
	Tracy	20.3 abx	25.9 ax	18.9 ax	21.7
	Centennial	26.1 ax	29.2 ax	27.3 ax	27.5
	Bragg	20.4 abx	26.1 abx	21.8 ax	22.8
	Average	18.8	23.4	20.5	
6/15	Hill	5.2 bx	2.8 abx	4.0 bcx	4.0
	Forrest	1.1 cx	1.1 bx	1.0 dx	1.1
	Tracy	13.8 ax	13.4 ax	2.2 cdx	9.8
	Centennial	13.1 ax	7.8 abx	7.3 ax	9.4
	Bragg	2.6 cy	3.3 abxy	4.4 bx	3.5
	Average	7.2	5.7	3.8	
6/29	Hill	6.6 bx	10.8 ax	8.4 ax	8.6
	Forrest	10.0 abx	10.7 ax	9.3 ax	10.0
	Tracy	11.0 abx	10.3 ax	9.2 ax	10.2
	Centennial	14.5 ax	10.9 ax	10.6 ax	12.0
	Bragg	11.9 ax	16.2 ax	10.5 ax	12.9
	Average	10.8	11.8	9.6	

end of table

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*Adjusted to 13% moisture.

1/ Within each row width and planting date, values followed by the same letter (a, b, or c) are not different at a probability of equal to or less than 0.05 as determined by Duncan's new Multiple Range Test. Values across row widths within a date and within a variety are not different if followed by the same letter (x, y, or z).

2/ Hill seed was of poor quality and, although planting rate was increased, the resulting yield may be artificially low. Hill was therefore excluded in data analysis.

3/ Plots not harvested due to poor stands.

Appendix Table 4. Yield of soybeans, by planting date, variety and row spacing, MAFES Coastal Plain Branch, 1977-79.

		Yield*		
		Row Width (inches)		
Planting Date	Variety	7	40	Average
		1977		
		--------- bushels/acre[1]	----------	
4/15	Hill	21.5 a x[1]	25.4 b x	23.4
	Forrest	28.7 a x	30.0 ab x	29.4
	Tracy	26.4 a x	35.8 a x	31.1
	Bragg	21.2 a x	28.0 b x	24.6
	Average	24.4	29.8	27.1
5/2	Hill	31.3 b x	29.1 a x	30.2
	Forrest	39.4 ab x	29.5 a x	34.4
	Tracy	43.5 a x	36.5 a y	40.0
	Bragg	33.0 b x	33.3 a x	33.2
	Average	36.8	32.1	34.5
5/16	Hill	37.7 a x	32.8 b x	35.2
	Forrest	37.1 a x	38.5 b x	37.8
	Tracy	47.7 a x	44.7 a x	46.2
	Bragg	37.6 a x	36.8 b x	37.2
	Average	40.0	38.2	39.1
		1978		
4/21	Hill	[2] --	[2] --	[2] --
	Forrest	11.3 a y	28.4 a x	19.8
	Tracy	7.6 a y	19.4 b x	13.5
	Bragg	11.2 a x	10.6 c x	10.9
	Average	10.0	19.5	14.7
5/2	Hill	[2] --	[2] --	[2] --
	Forrest	[2] --	29.1 a	[2] --
	Tracy	[2] --	17.1 b	[2] --
	Bragg	7.6 x	9.5 c x	8.6
	Average			
5/22[3]	Hill	29.0 a x	29.2 a x	29.1
	Forrest	27.6 a x	22.2 ab y	24.9

continued

Appendix Table 4. (Continued)

Planting Date		Yield* Row Width (inches) 7	40	Average
		---------------bushels/acre	------------	
	Tracy	14.9 b x	19.0 b x	17.0
	Bragg	14.3 b x	12.9 c x	13.6
	Average	21.4	20.8	21.2
6/6 3/	Hill	12.7 b y	23.6 a x	18.2
	Forrest	19.6 a x	21.8 a x	20.7
	Tracy	12.9 b y	20.0 a x	16.4
	Bragg	15.0 b x	15.9 b x	15.4
	Average	15.0	20.3	17.7
		1979		
5/3	Hill	20.4 ax	29.0 ax	24.7
	Forrest	21.9 ax	29.2 ax	25.5
	Tracy	23.9 ay	36.2 ax	30.0
	Bragg	25.1 ax	33.3 ax	29.2
	Average	24.0	31.9	27.4
5/28	Hill	41.7 abx	33.0 ax	37.3
	Forrest	45.8 ax	34.3 ax	40.0
	Tracy	38.1 bx	28.9 ax	33.5
	Bragg	39.5 abx	35.1 ax	36.3
	Average	41.3	32.8	36.8
6/14	Hill	32.8 ax	33.7 bx	33.2
	Forrest	32.3 ax	37.2 abx	34.7
	Tracy	37.3 ax	36.4 abx	36.9
	Bragg	43.3 ax	40.1 ax	41.7
	Average	36.4	36.9	36.6
6/27	Hill	36.7 ax	27.4 by	32.0
	Forrest	39.9 ax	27.8 by	33.9
	Tracy	39.3 ax	30.9 bx	35.1
	Bragg	44.0 ax	35.6 ay	39.8
	Average	40.0	30.4	35.2

end of table

*Adjusted to 13% moisture.

[1] Within each row width and planting date, values followed by the same letter (a or b) are not different at a probability of equal to or less than 0.05 as determined by Duncan's New Multiple Range Test. Values across row widths, within a date and within a variety are not different if followed by the same letter (x or y).

[2] Not harvested because of poor stand.

[3] New source of Hill seed.

Appendix Table 5. Yield of soybeans, by planting date, variety and row spacing, MAFES Brown Loam Branch, 1976-79.

		Yield*		
		Row Width (inches)		
Planting Date	Variety	7	40	Average
		1976		
		------- bushels/acre[1]	-----------	
4/19	Kent	33.5 a[1]	28.3 a	30.9
	Hill	35.0 a	36.6 a	35.8
	Forrest	39.8 a	39.8 a	39.8
	Tracy	44.2 a	41.3 a	42.8
	Lee 74	41.1 a	37.0 a	39.0
	Bragg	33.6 a	34.5 a	34.0
	Average	37.9	36.2	37.1
5/05	Kent	43.7 a	29.2 c	36.4
	Hill	32.3 a	39.2 abc	35.8
	Forrest	38.3 a	31.5 bc	34.9
	Tracy	48.1 a	41.2 ab	44.6
	Lee 74	42.1 a	46.6 a	44.4
	Bragg	43.0 a	36.8 abc	39.9
	Average	41.2	37.4	39.3
5/19	Kent	45.3 a	35.3 b	40.3
	Hill	39.9 a	40.2 ab	40.0
	Forrest	46.3 a	47.0 a	46.6
	Tracy	36.0 a	39.5 b	37.8
	Lee 74	44.9 a	38.9 b	41.9
	Bragg	39.2 a	35.2 b	37.2
	Average	41.9	39.4	40.6
6/04	Kent	12.5 a	10.4 c	11.4
	Hill	23.6 a	17.0 b	20.3
	Forrest	24.3 a	16.2 b	20.2
	Tracy	17.4 a	20.3 ab	18.8
	Lee 74	22.1 a	22.2 a	22.2
	Bragg	23.0 a	22.1 a	22.6
	Average	20.5	18.0	19.3

continued

Appendix Table 5. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	40	Average
		----------bushels/acre----------		
7/01	Kent	10.8 b	12.7 b	11.8
	Hill	23.9 a	15.3 ab	19.6
	Forrest	20.6 a	17.2 ab	18.9
	Tracy	20.0 a	15.3 ab	17.6
	Lee 74	22.7 a	18.5 a	20.6
	Bragg	24.2 a	17.6 ab	20.9
	Average	20.4	16.1	18.2
7/16	Kent	7.3 ab	--[3/]	--
	Hill	13.7 a	10.9 a	12.3
	Forrest	12.7 ab	6.9 a	9.8
	Tracy	6.4 b	7.0 a	6.7
	Lee 74	11.8 ab	8.9 a	10.4
	Bragg	7.8 ab	11.7 a	9.8
	Average	9.9	8.9	9.8
		1977		
4/29	Hill	18.8 d x	18.7 b x	18.8
	Forrest	24.1 cd x	25.1 b x	24.6
	Tracy	39.0 a x	38.1 a x	38.5
	Centennial	36.5 ab x	39.7 a x	38.1
	Bragg	28.3 bc x	34.0 a x	31.2
	Average	39.3	31.1	30.2
6/22	Hill	20.6 b x	18.8 b x	19.7
	Forrest	24.0 ab y	29.3 a x	26.7
	Tracy	28.4 a x	29.0 a x	28.7
	Centennial	18.4 b y	27.8 a x	23.1
	Bragg	21.8 b x	27.7 a x	24.8
	Average	22.6	26.5	24.6
7/6	Hill	13.9 b x	14.1 c x	14.0
	Forrest	13.4 b y	18.1 bc x	15.8
	Tracy	18.6 a y	17.4 c x	18.0
	Centennial	14.7 b y	22.2 ab x	18.5
	Bragg	20.2 a x	23.3 a x	21.8
	Average	16.2	19.0	17.6

continued

Appendix Table 5. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	40	Average
		------------bushels/acre	------------	------------
7/27	Hill			2.7
	Forrest	Not harvested due to		3.4
	Tracy	insect damage		2.9
	Centennial			3.0
	Bragg			2.5
		1978		
4/27 [3]	Hill	18.3	22.1	20.2
	Forrest	25.0 b x	28.4 a x	26.7
	Tracy	26.1 b x	34.3 a x	30.2
	Centennial	37.2 a x	33.8 a x	35.5
	Bragg	37.2 a x	34.8 a x	36.0
	Average	31.4	32.8	32.1
5/24	Hill	28.1	31.9	30.0
	Forrest	32.7 a x	30.8 b x	31.8
	Tracy	34.4 a x	34.9 ab x	34.6
	Centennial	34.9 a x	4.05 a x	37.7
	Bragg	37.7 a x	31.4 b x	34.6
	Average	35.0	34.4	34.7
6/21	Hill	26.1	22.2	24.2
	Forrest	30.4 a x	27.8 a x	29.1
	Tracy	30.2 a x	30.9 a x	30.6
	Centennial	35.8 a x	38.2 a x	37.0
	Bragg	35.9 a x	30.8 a x	33.4
	Average	33.1	31.9	32.5
7/12	Hill	[4] --	[4] --	[4] --
	Forrest	14.0 a x	11.5 a x	12.8
	Tracy	11.4 a x	10.4 a x	10.9
	Centennial	14.2 a x	16.3 a x	15.2
	Bragg	19.1 a x	14.3 a x	16.7
	Average	14.7	13.1	13.9

continued

Appendix Table 5. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	40	Average
		1979		
		---------------bushels/acre---------------		
4/19	Hill	25.8 bx	33.5 bx	29.7
	Forrest	33.0 abx	42.6 abx	37.8
	Tracy	31.7 abx	39.1 abx	35.4
	Centennial	35.7 ay	49.6 ax	42.6
	Bragg	32.5 aby	43.9 abx	38.2
	Average	31.7	41.7	36.7
5/28	Hill	39.0 bx	32.6 bx	35.8
	Forrest	43.0 bx	34.8 bx	38.9
	Tracy	45.0 abx	39.8 abx	42.4
	Centennial	53.5 ax	43.4 ax	48.5
	Bragg	43.2 bx	40.4 abx	41.8
	Average	44.8	38.2	41.5
6/29	Hill	33.2 cx	30.6 cx	31.9
	Forrest	42.9 ax	35.6 bcy	39.2
	Tracy	36.9 bx	35.2 bcx	36.0
	Centennial	42.4 ax	43.5 ax	43.0
	Bragg	41.7 ax	37.4 by	39.6
	Average	39.4	36.4	37.9
7/20	Hill	24.6 bx	20.0 bx	22.3
	Forrest	31.5 ax	22.9 aby	27.2
	Tracy	26.9 abx	17.7 by	22.3
	Centennial	28.4 abx	26.1 ax	27.3
	Bragg	31.3 ax	22.1 aby	26.7
	Average	28.6	21.7	25.2

end of table

*Adjusted to 13% moisture.

1/ Within each row width and planting date, values followed by the same letter (a, b, or c) are not different at a probability of equal to or less than 0.05 as determined by Duncan's New Multiple Range Test. Values across row widths, within a date and within a variety are not different if followed by the same letter (x or y).

2/ Plots not harvested due to shattering.

[3] Hill seed was of poor quality and, although planting rate was increased, the resulting yield may be artificially low. Hill was therefore excluded in the data analysis.

[4] Was not harvested because of poor stand.

Appendix Table 6. Yield of soybeans, by planting date, variety and planting date, MAFES South Mississippi Branch, 1976-79.

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		1976			
		------------ bushels/acre --------------			
4/28	Hill	47.4 a[1/]	25.9 ab	29.4 ab	34.2 a
	Forrest	27.5 ab	20.3 b	25.5 b	24.4 b
	Pickett 71	23.5 b	26.2 ab	28.8 ab	26.1 ab
	Davis	25.7 ab	18.1 b	27.0 b	23.6 b
	Bragg	33.7 ab	34.1 a	33.0 ab	33.6 a
	Cobb	33.8 ab	26.2 ab	36.1 a	32.0 ab
	Average	31.9	25.1	29.9	29.0
5/13	Hill	33.6 ab	25.2 b	22.2 bc	27.0 bc
	Forrest	28.7 b	17.5 c	23.2 bc	23.2 cd
	Pickett 71	38.7 ab	31.1 ab	27.7 ab	32.5 ab
	Davis	22.9 b	14.8 c	16.5 c	18.0 d
	Bragg	53.3 a	34.4 a	32.2 a	40.0 a
	Cobb	44.4 ab	26.6 b	29.5 ab	33.5 ab
	Average	36.9	24.9	25.2	29.0
6/18	Hill	24.6 ab	19.7 a	16.5 b	20.2 ab
	Forrest	33.8 a	22.8 a	23.8 a	26.8 a
	Pickett 71	22.3 ab	17.5 a	19.3 ab	19.7 b
	Davis	21.0 ab	19.8 a	22.8 a	21.2 ab
	Bragg	35.3 a	24.3 a	20.4 ab	26.7 a
	Cobb	17.5 b	21.5 a	19.0 ab	19.3 b
	Average	25.7	20.9	20.3	22.3
		1977			
4/28	Hill	11.6 c x	9.7 d xy	3.8 c y	8.4 c
	Forrest	19.0 bc x	14.3 cd x	6.8 c x	13.4 c
	Pickett 71	28.1 ab x	21.8 bc x	13.6 bc x	21.1 b
	Davis	29.1 ab x	29.6 ab x	28.8 a x	29.1 a
	Bragg	30.2 ab x	38.0 ab x	19.2 ab x	25.8 ab
	Cobb	36.4 a x	35.8 a x	26.6 a x	32.9 a

continued

Appendix Table 6. (Continued)

Planting Date	Variety	Yield* Row Width (inches) 7	30	40	Average
		------------bushels/acre-------------------			
	Average	25.7	24.9	16.5	
5/12	Hill	18.9 a x	19.6 a x	17.6 a x	18.7 b
	Forrest	32.4 a x	26.2 a x	18.9 a x	25.8 ab
	Pickett 71	32.8 a x	23.6 a x	23.4 a x	26.6 ab
	Davis	34.2 ax	22.5 ax	23.5 ax	26.7 ab
	Bragg	29.7 ax	21.2 ax	20.0 ax	23.6 ab
	Cobb	34.8 ax	24.0 ax	26.5 ax	28.4 a
	Average	30.5	22.8	21.7	
[2] 6/2	Hill		11.1	14.8	
	Forrest		12.4	15.6	
	Pickett 71		26.4	17.8	
	Davis		28.8	16.5	
	Bragg		24.6	14.6	
	Cobb		30.0	24.5	
	Average		22.2	17.3	
			1978		
4/21 [3]	Hill	29.1	22.6	18.6	23.4
	Forrest	37.8 a x	25.10 a xy	22.8 by	28.6
	Pickett 71	38.1 a x	25.6 a x	35.0 a x	32.9
	Davis	34.4 a x	33.1 a x	35.6 a x	34.4
	Bragg	30.7 a x	30.0 a x	30.5 ab x	30.4
	Cobb	31.6 a x	26.2 a x	30.9 ab x	29.6
	Average	34.5	28.0	31.0	31.2
5/11	Hill	27.6	29.6	19.7	25.6
	Forrest	36.2 ab x	30.7 ab xy	25.6 a y	30.8
	Pickett 71	39.2 ab x	33.6 ab x	26.9 a x	33.2
	Davis	41.1 a x	38.0 a x	33.6 a x	37.6
	Bragg	28.2 b x	23.5 b x	31.9 a x	27.9
	Cobb	41.4 a x	29.8 ab y	31.3 a y	34.2
	Average	37.2	31.1	29.9	32.7

continued

Appendix Table 6. (Continued)

		Yield*			
		Row Width (inches)			
Planting Date	Variety	7	30	40	Average
		--------------bushels/acre--------------------			
6/12	Hill	28.3	25.4	15.3	23.0
	Forrest	30.7 a x	30.5 a x	21.5 b x	27.6
	Pickett 71	39.4 a x	22.5 a y	21.4 b y	27.8
	Davis	34.3 a x	26.6 a x	23.6 ab x	28.2
	Bragg	30.1 a x	25.1 a x	20.4 b x	25.2
	Cobb	42.6 a x	30.8 a x	30.0 a x	34.5
	Average	35.4	27.1	23.4	28.7
			1979		
4/17	Hill	0 by	16.5 cx	13.1 cx	9.8
	Forrest	0 by	17.5 cx	16.9 bcx	11.5
	Pickett 71	0 by	19.9 cx	17.6 bcx	12.5
	Davis	20.1 ay	33.5 ax	24.5 bxy	26.1
	Bragg	23.5 axy	26.9 bx	18.3 bcy	22.8
	Cobb	0 by	35.9 ax	38.7 ax	24.8
	Average	7.3	25.0	21.5	
5/3	Hill	21.5 bx	20.9 cx	19.7 cx	20.7
	Forrest	20.5 bx	27.1 cx	21.0 cx	22.9
	Pickett 71	22.9 bx	32.9 bx	29.8 bx	28.5
	Davis	41.0 ax	37.5 abx	30.2 bx	36.3
	Bragg	40.3 ax	37.0 abx	32.7 abx	36.7
	Cobb	52.6 ax	41.1 ay	37.9 ay	43.9
	Average	33.2	32.8	28.6	
5/18	Hill	28.0 bx	26.8 cdx	17.4 cy	24.1
	Forrest	32.3 bx	20.8 dy	25.6 bxy	26.2
	Pickett 71	28.2 bx	30.4 bcx	30.9 abx	29.8
	Davis	34.3 bx	35.1 abx	32.0 abx	33.8
	Bragg	36.7 bx	37.7 abx	26.1 by	33.5
	Cobb	58.7 ax	40.0 ay	35.9 ay	44.8
	Average	36.4	31.8	28.0	

end of table

*Adjusted to 13% moisture.

[1] Within each row width and planting date, values followed by the same letter (a, b, c or d), are not different at a probability of equal to or less than 0.05 as determined by Duncan's New Multiple Range Test. Values across row widths, within a date and within a variety, are not different if followed by the same letter (x or y).

[2] Data in the June 2 planting were not included in analysis because drilled plots were not harvested due to poor stands caused by severe drought at planting. The data reported in this planting are averages of 3 replications.

[3] Hill seed was of poor quality and, although planting rate was increased, the resulting yield may be artificially low. Hill was therefore excluded in the data analysis.

Appendix Table 7. Rainfall (inches) by weeks, months, years and locations of test sites.

Month	Week	Rainfall Verona	 Starkville	 Brooksville	 Newton	 Raymond	 Poplarville
		-----------	-----------	-----------	inches	-----------	-----------
				1976			
April	1-7	0.0	0.0	0.0		0.0	0.0
	8-14	0.4	0.0	0.0		0.0	0.0
	15-21	0.5	0.0	0.0		0.3	0.2
	22-28	0.7	1.1	1.9		1.0	1.2
	29-30	0.2	0.0	0.1		0.1	0.5
	Monthly Total	1.8	1.1	2.0		1.4	1.9
May	1-7	0.0	2.0	1.5		0.4	1.2
	8-14	2.0	2.7	2.9		3.8	1.0
	15-21	0.8	1.3	0.8		0.5	0.0
	22-28	0.7	0.4	0.9		1.4	1.9
	29-31	0.3	0.0	0.0		0.0	0.0
	Monthly Total	3.8	6.4	6.1		6.1	4.1
June	1-7	1.9	1.6	2.1		0.5	0.7
	8-14	0.0	0.0	0.0		0.0	0.0
	15-21	2.5	1.2	1.9		1.4	1.1
	22-28	0.6	1.2	1.3		1.5	0.3
	29-30	0.0	0.2	0.0		1.1	1.6
	Monthly Total	5.0	4.2	5.3		4.5	3.7

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall					
		Verona	Starkville	Brooksville	Newton	Raymond	Poplarville
		--inches--					
July	1-7	0.4	1.7	2.0		2.4	4.9
	8-14	0.3	0.0	0.0		0.0	0.2
	15-21	0.1	0.1	0.0		0.5	0.2
	22-28	0.4	3.1	0.2		0.0	0.9
	29-31	0.5	0.2	0.4		0.0	1.2
	Monthly Total	1.7	5.1	2.6		2.9	7.4
August	1-7	0.0	0.3	0.9		0.3	1.9
	8-14	0.0	0.0	0.0		0.0	0.0
	15-21	0.4	0.4	5.1		0.0	0.2
	22-28	3.4	0.0	0.0		1.2	0.4
	29-31	1.2	0.1	0.0		0.0	2.0
	Monthly Total	5.0	0.8	6.0		1.5	4.5
September	1-7	3.2	1.5	2.6		0.3	3.1
	8-14	0.7	1.8	2.8		0.0	0.0
	15-21	0.4	0.9	0.0		0.1	0.0
	22-28	0.4	0.6	0.0		0.0	0.2
	29-30	0.1	0.3	0.0		0.3	0.0
	Monthly Total	4.8	5.1	5.4		0.7	3.3
October	1-7	1.2	1.2	1.2		0.0	-1/
	8-14	0.1	0.0	0.0		0.0	0.0
	15-21	1.0	0.3	0.5		0.0	1.5
	22-28	1.2	0.8	1.1		0.1	1.3
	29-31	1.2	1.0	0.8		1.2	2.9

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall Verona	 Starkville	 Brooksville	 Newton	 Raymond	 Poplarville
		inches					
	Monthly Total	4.7	3.3	3.6		1.3	-
1977							
April	1-7	5.2	6.5	2.9	3.6	6.0	0.5
	8-14	0.0	0.0	0.0	0.0	0.0	0.0
	15-21	0.2	2.6	0.2	0.9	0.6	3.0
	22-28	1.4	0.0	3.7	3.6	3.0	0.8
	29-30	0.0	0.0	0.0	0.0	0.0	0.0
	Monthly Total	6.8	9.1	6.8	8.1	9.6	4.3
May	1-7	0.7	0.4	0.3	1.4	0.6	2.6
	8-14	0.0	0.0	0.1	0.0	0.0	0.1
	15-21	0.0	0.0	0.0	0.0	0.0	0.0
	22-28	0.1	0.1	0.0	0.4	0.1	0.3
	29-31	0.3	0.0	1.4	0.6	0.0	0.2
	Monthly Total	1.1	0.5	1.8	2.4	0.7	3.2
June	1-7	0.3	0.1	0.0	0.5	0.1	0.9
	8-14	0.0	0.0	0.0	0.4	0.0	0.0
	15-21	0.8	0.6	0.2	0.6	1.0	0.2
	22-28	0.1	0.1	0.6	1.1	0.6	0.2
	29-30	0.0	0.1	0.1	0.0	0.0	0.0
	Monthly Total	1.2	0.9	0.9	2.6	1.7	1.3

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall					
		Verona	Starkville	Brooksville	Newton	Raymond	Poplarville
		---inches---					
July	1-7	0.0	0.3	0.0	0.0	1.4	1.6
	8-14	2.7	3.2	4.5	1.5	1.2	1.8
	15-21	1.9	0.5	0.6	1.5	1.6	1.7
	22-28	0.5	3.7	3.0	1.5	1.0	1.6
	29-31	0.5	1.0	1.3	3.2	0.0	1.4
	Monthly Total	5.6	8.7	9.4	7.7	5.2	8.1
August	1-7	0.0	0.0	0.0	1.1	0.1	0.4
	8-14	0.0	0.0	0.0	0.0	0.0	1.5
	15-21	1.0	0.9	0.0	0.6	1.3	4.2
	22-28	0.0	0.0	0.2	0.0	0.0	0.8
	29-31	0.0	0.0	0.0	0.2	0.6	1.3
	Monthly Total	1.0	0.9	0.2	1.9	2.0	8.2
September	1-7	0.9	2.9	5.2	4.2	0.9	2.7
	8-14	0.8	1.8	0.9	0.9	0.0	2.5
	15-21	2.3	1.6	1.9	0.4	0.7	0.3
	22-28	1.8	0.5	0.4	0.0	0.0	0.3
	29-30	0.9	0.9	1.3	2.1	1.0	0.9
	Monthly Total	6.7	7.7	9.7	7.6	2.6	6.7
October	1-7	0.9	0.0	0.0	0.7	1.8	0.4
	8-14	1.7	2.9	2.1	1.1	2.6	1.1
	15-21	0.0	0.0	0.0	0.0	0.0	0.0
	22-28	2.2	2.1	2.2	5.1	0.3	1.4
	29-31	0.0	0.0	0.0	0.0	0.0	0.0

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall Verona	 Starkville	 Brocksville	 Newton	 Raymond	 Poplarville
		----------	----------	-----	inches	----------	----------
	Monthly Total	4.8	5.0	4.3	6.9	4.7	2.9
				1978			
April	1-7	0.0	0.0	0.0	0.0	0.0	0.0
	8-14	1.1	0.8	0.8	2.9	1.3	2.9
	15-21	1.2	0.0	0.3	0.4	1.3	1.2
	22-28	0.3	0.0	0.2	0.4	0.7	0.1
	29-30	0.0	0.0	0.0	0.0	0.0	0.0
	Monthly Total	2.6	0.8	1.3	3.7	3.3	4.2
May	1-7	7.0	1.5	3.0	2.1	4.4	4.1
	8-14	2.0	5.8	4.6	3.0	3.1	1.5
	15-21	0.1	1.0	0.2	0.3	0.4	0.8
	22-28	1.2	0.5	2.3	0.4	0.3	0.1
	29-31	1.9	1.7	0.6	0.0	1.3	0.0
	Monthly Total	12.2	10.5	10.7	5.8	9.5	6.5
June	1-7	0.7	1.2	0.4	0.5	0.5	2.0
	8-14	0.9	0.0	0.5	1.7	0.7	6.3
	15-21	1.2	2.0	1.2	0.1	1.1	0.0
	22-28	0.0	0.0	0.0	0.2	0.0	0.1
	29-30	0.0	0.0	0.0	0.0	0.0	0.0
	Monthly Total	2.8	3.2	2.1	2.5	2.3	8.4

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall					
		Verona	Starkville	Brooksville	Newton	Raymond	Poplarville
		---inches---					
July	1-7	0.0	0.1	0.3	1.7	0.0	0.2
	8-14	1.3	1.3	0.0	0.4	1.4	0.5
	15-21	0.0	0.4	1.5	0.3	1.7	0.0
	22-28	0.4	0.0	0.0	0.8	0.3	3.3
	29-31	0.0	0.0	0.0	0.1	0.0	1.8
	Monthly Total	1.7	1.8	1.8	3.3	3.4	5.8
August	1-7	1.0	0.2	0.0	0.4	0.0	1.9
	8-14	0.3	1.7	1.3	1.8	0.3	3.3
	15-21	0.0	0.0	0.0	0.6	0.3	0.4
	22-28	0.0	0.0	0.0	0.0	0.0	0.9
	29-31	0.1	0.1	0.2	0.1	2.6	0.2
	Monthly Total	1.4	2.0	1.5	2.9	3.2	6.7
September	1-7	0.0	0.7	0.0	0.0	0.2	0.0
	8-14	0.3	1.3	0.3	0.4	0.1	1.3
	15-21	1.9	0.0	1.5	0.0	0.5	0.0
	22-28	0.1	0.0	0.1	0.0	0.7	2.4
	29-30	0.0	0.0	0.0	0.0	0.0	0.3
	Monthly Total	2.3	2.0	1.9	0.4	1.5	4.0
October	1-7	0.0	0.0	0.0	0.0	0.0	0.0
	8-14	0.2	0.3	0.0	0.2	0.9	0.0
	15-21	0.0	0.0	0.0	0.0	0.0	0.0

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall					
		Verona	Starkville	Brooksville	Newton	Raymond	Poplarville
		inches					
	22-28	0.0	0.0	0.0	0.0	0.0	0.0
	29-31	0.0	0.0	0.0	0.0	0.0	0.0
	Monthly Total	0.2	0.3	0.0	0.2	0.9	0.0
1979							
April	1-7	2.8	2.4	2.1	3.5	3.1	7.0
	8-14	4.8	13.2	16.2	7.4	6.1	0.4
	15-21	0.9	0.0	0.0	0.0	0.0	0.0
	22-28	0.0	0.8	0.8	1.4	1.3	6.3
	29-30	0.0	0.0	0.0	0.0	0.0	0.0
	Monthly Total	6.6	16.4	19.1	12.3	10.5	13.7
May	1-7	3.5	0.0	1.1	1.6	0.8	3.3
	8-14	1.2	0.0	2.8	0.1	2.4	1.3
	15-21	0.0	0.0	0.0	0.0	0.0	0.0
	22-28	1.3	1.4	0.7	1.7	1.0	0.4
	29-31	3.6	0.5	1.9	1.3	1.3	1.6
	Monthly Total	9.6	1.9	6.5	4.7	5.5	6.6
June	1-7	0.8	0.2	0.4	1.6	1.4	0.4
	8-14	0.6	1.3	0.0	0.1	0.0	0.2
	15-21	0.0	0.1	0.0	0.0	0.0	0.0
	22-28	1.9	0.6	1.1	0.3	0.8	0.0
	29-30	0.0	0.1	0.0	0.0	0.0	0.4

continued

Appendix Table 7. (Continued).

Month	Week	Rainfall					
		Verona	Starkville	Brooksville	Newton	Raymond	Poplarville
		--------------------------inches--------------------------					
	Monthly Total	3.3	2.3	1.5	2.0	2.2	1.0
July	1-7	4.9	1.4	1.7	0.5	0.3	0.0
	8-14	2.3	7.8	4.0	5.5	3.1	4.5
	15-21	0.1	1.1	1.0	0.7	0.6	1.2
	22-28	1.7	1.8	1.4	1.9	0.8	6.2
	29-31	0.0	0.3	0.2	0.0	0.0	0.0
	Monthly Total	9.0	12.3	8.3	8.6	4.8	11.9
August	1-7	1.0	0.0	0.2	1.7	0.2	0.4
	8-14	0.3	0.1	2.2	1.5	0.5	0.1
	15-21	0.2	0.0	0.0	0.0	0.3	0.5
	22-28	4.0	0.0	1.3	2.5	3.8	1.7
	29-31	0.2	0.4	0.0	0.0	0.0	0.0
	Monthly Total	5.7	0.5	3.7	5.7	4.8	2.7
September	1-7	1.0	0.7	1.1	0.2	0.2	1.1
	8-14	3.5	4.0	4.3	3.9	0.2	2.5
	15-21	2.6	5.3	3.9	2.9	3.3	1.8
	22-28	0.0	0.0	0.0	0.0	0.0	0.0
	29-30	0.0	0.0	0.0	0.0	0.0	0.0
	Monthly Total	7.1	10.0	5.3	7.0	3.7	5.4

continued

Appendix Table 7. (Continued)

Month	Week	Rainfall					
		Verona	Starkville	Brooksville	Newton	Raymond	Poplarville
		--inches--					
October	1-7	1.0	1.2	0.9	0.0	0.0	0.0
	8-14	0.3	0.1	0.1	0.2	0.1	0.0
	15-21	0.0	0.3	0.0	0.0	0.0	0.0
	22-28	0.5	0.0	0.0	0.0	0.5	0.6
	29-31	0.1	0.6	0.1	0.8	1.6	1.0
	Monthly Total	1.9	2.2	1.1	1.0	2.2	1.6

end of table

1/ Rainfall not recorded.

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Establishment & Maintenance of Muscadine Vineyards

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Establishment and Maintenance of Muscadine Vineyards

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Preface

Establishing a vineyard requires a large capital investment over a three-year period (as much as $4,000/acre at 1983 prices), and maintaining a vineyard is labor intensive and costly. Consequently, establishing a vineyard without careful preplanning is an exercise of poor judgment. Some of the more important considerations in preplanning may be in the form of questions as follow:

1. Do I have an acceptable vineyard site?
2. Do I plan to produce muscadines for wine or for other uses? (The answer will determine the choice of varieties.)
3. Where can I get plants of the varieties I wish to grow?
4. What machinery do I need?
5. Do I need an irrigation system; if so, what types of systems are available and which is best for me?
6. What kind of trellises do I need and what kinds of trellis materials are best?
7. Do I know enough about the growth habits of muscadines to permit proper training and pruning of the vines?
8. What disease and insect problems can I expect?
9. Am I equipped and staffed to handle the harvest?

These questions are addressed in the Appendix to this bulletin. The Appendix also contains a list of references that may be helpful to those interested in more detail than an abbreviated appendix permits.

Given the decision to establish a vineyard, how do you proceed? The first steps are selecting a vineyard site and liming it to bring soil pH to 7.0, making a plat of the proposed vineyard, deciding what varieties to grow and determining machinery needs. All other steps follow a logical sequence, and instructions for accomplishing each step are presented in this bulletin.

The growth habits of muscadines dictate the tasks required for vineyard management. The time of performance and instructions for accomplishing each step are presented in this bulletin.

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Establishment & Maintenance of Muscadine Vineyards

Vineyard Establishment

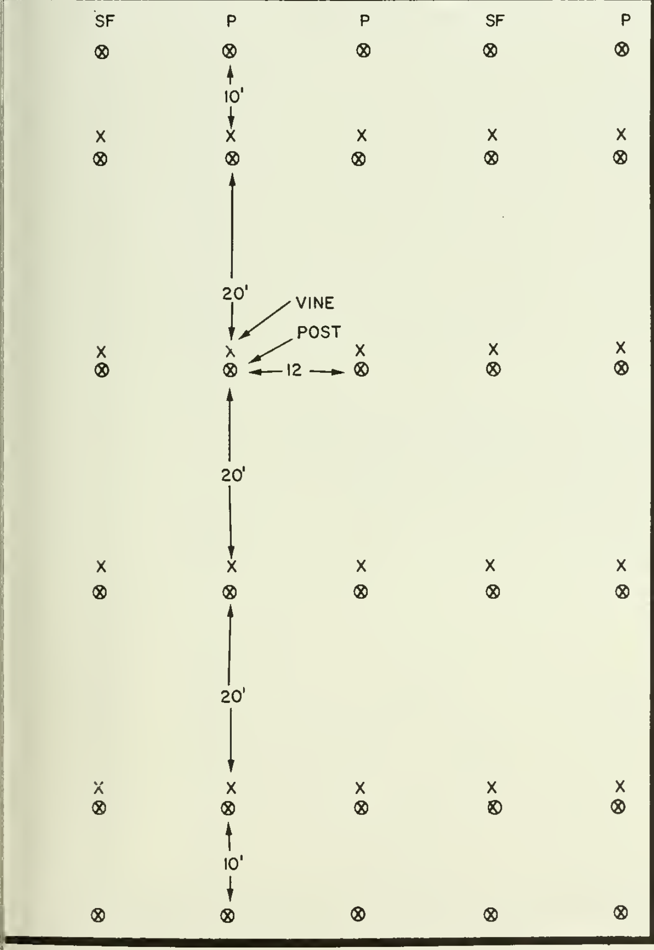
elect the vineyard site, have the tested and apply lime to bring to 7.0. Apply and incorporate e before performing any of the rations required for vineyard ablishment. Applying lime is ch more difficult after the vines set and the vine-support system nstalled.

etermine row direction and make at of the vineyard. Space rows ft apart and trellis posts and nts 20 ft apart---with plants by trellis posts (Figure 1) or 10 ft n them (Figure 2). This planting tern gives about 180 vines/acre. *Setting vines midway between the trellis posts requires fewer posts, and harvesting with catch frames is easier and better than if vines are set by posts.*

If trickle irrigation is to be used, select the system. *The system that requires the least tubing* (Figure 3) *must be installed before the trellis posts are installed and the vines are set.* The other system (Figure 4) may be installed after the trellis posts are installed and the vines are set.

Determine the type of trellis to be used and install it. (Note: The trellises and the trickle irrigation system shown in Figure 4 may be installed after the vines are set; however, installing these support systems after vines are set increases the likelihood of vine damage. Also, young vines normally require water during or immediately after planting, and training of vines begins soon after the newly planted vines break dormancy. Performance of these two steps in vineyard establishment is much easier if the support systems are in place.)

Determine the variety or varieties to be planted. The use for which the



e 1. Plat of a vineyard with vines set by the trellis posts arieties with pistillate flowers, SF = varieties with self- flowers)

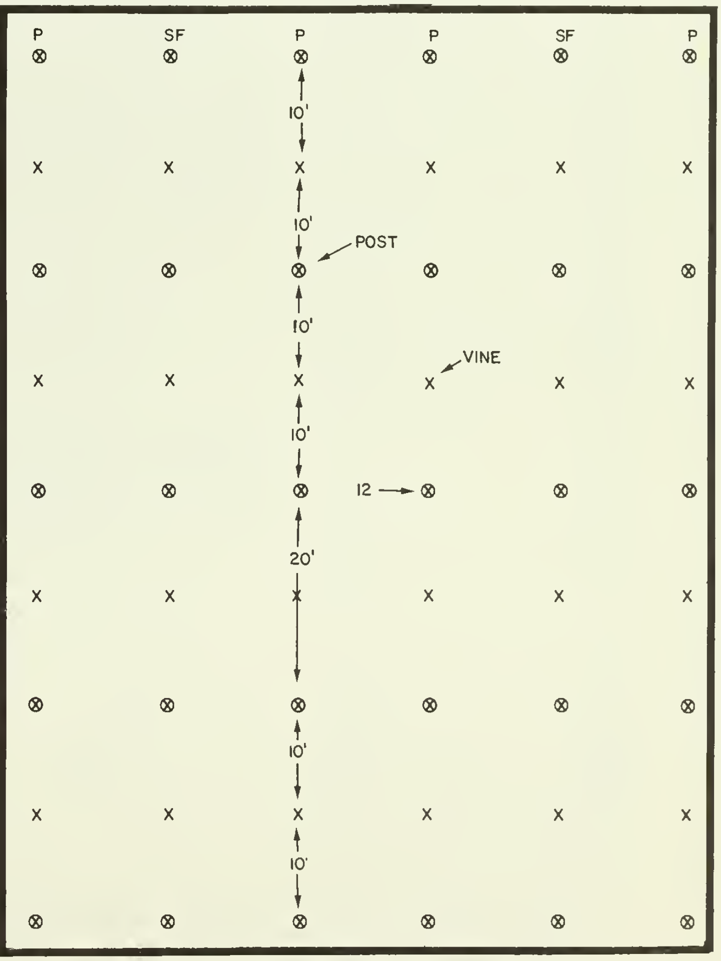


Figure 2. Plat of a vineyard with vines set 10′ from the trellis posts (P = varieties with pistillate flowers, SF = varieties with self-fertile flowers)

berries are intended dictates the choice of varieties. The varieties that researchers have found to be best for the various uses are presented in the Appendix to this bulletin.

An overriding consideration in the selection of varieties is whether they have self-fertile flowers or pistillate flowers. Varieties with self-fertile flowers do not require pollinators, and those with pistillate flowers do. *The recommended planting pattern in a vineyard containing pistillate varieties is one row of self-fertile varieties between two rows of pistillate varieties.* Designate the planting pattern, by varieties, on the vineyard plat (Figures 1 and 2).

Determine machinery needs. A tractor is required for site preparation and for setting trellis posts. A tractor of any size will suffice, but size of tractor selected should be based on the limits set on tractor size by vineyard management practices (See machinery needs, page 8).

Provide good trafficability, erosion control and nitrificatio the soil by maintaining a co crop such as a combination of gr and clover. Confine cover crops an 8 ft-wide strip between the ro (Figure 5). Never let grass, clove weeds grow under the trel Manage the clover stand to per reseeding each year. Mow warm cool-season grass cover cro frequently to prevent reseedi (heading out) and to maintai neat appearance of the vineya floor.

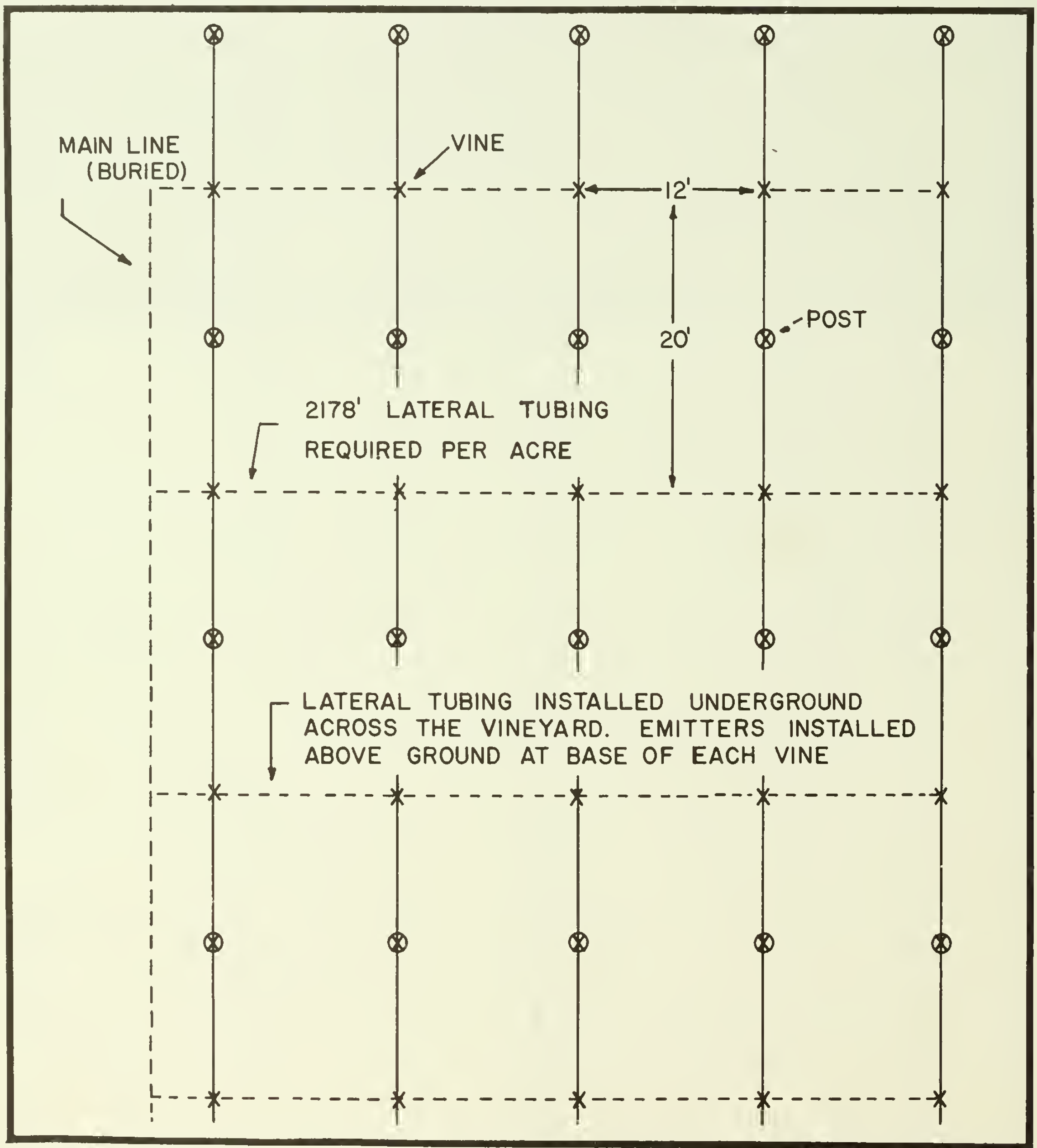
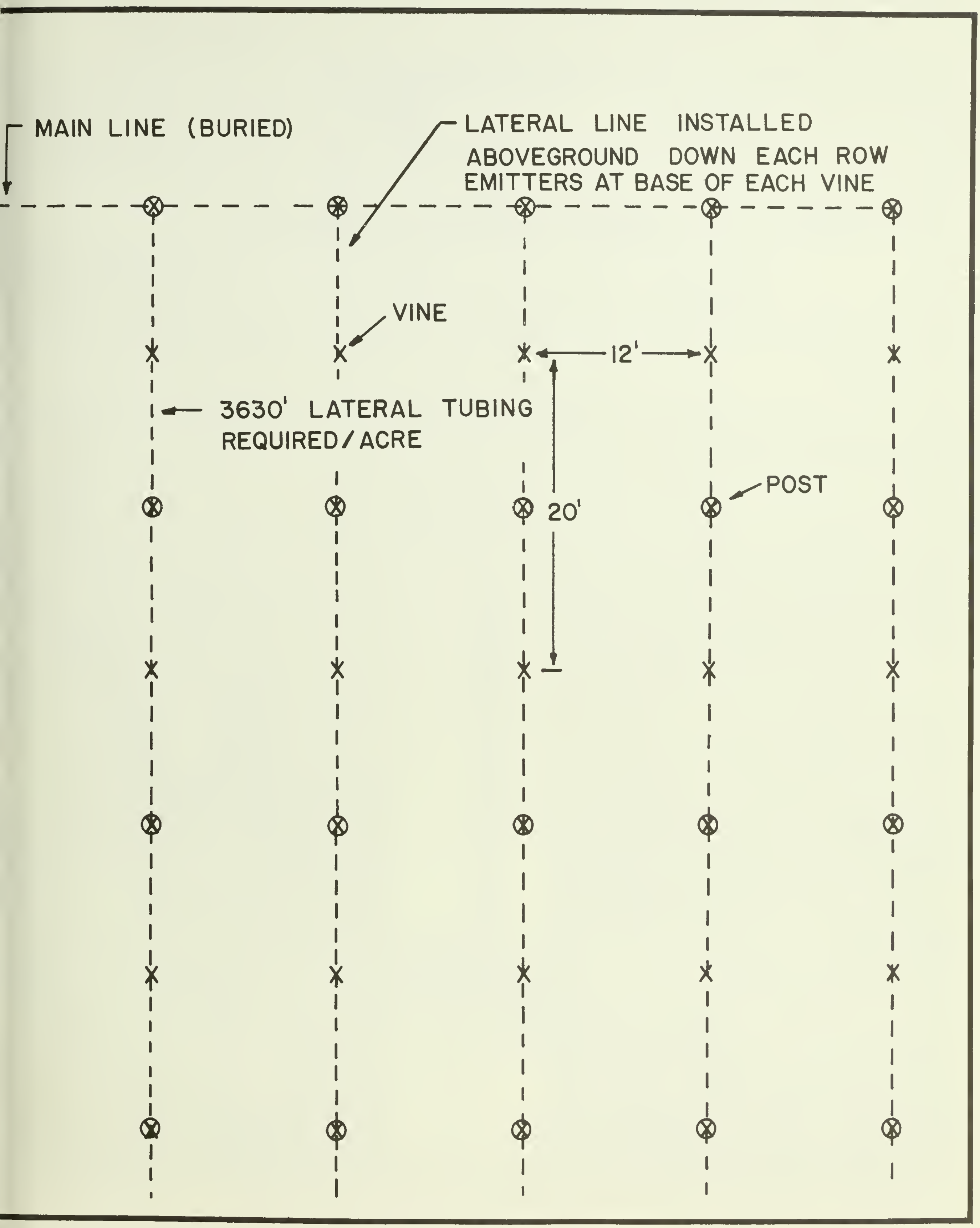

MAIN LINE
(BURIED)
VINE
12'
20'
POST
2178' LATERAL TUBING
REQUIRED PER ACRE
LATERAL TUBING INSTALLED UNDERGROUND
ACROSS THE VINEYARD. EMITTERS INSTALLED
ABOVE GROUND AT BASE OF EACH VINE

Figure 3. Design of the trickle irrigation system that requires only 2178′ of lateral tubing per acre


MAIN LINE (BURIED)
LATERAL LINE INSTALLED ABOVEGROUND DOWN EACH ROW
EMITTERS AT BASE OF EACH VINE
VINE
12'
3630' LATERAL TUBING REQUIRED/ACRE
20'
POST

re 4. Design of the trickle irrigation system that requires 3630′ of lateral tubing per acre.

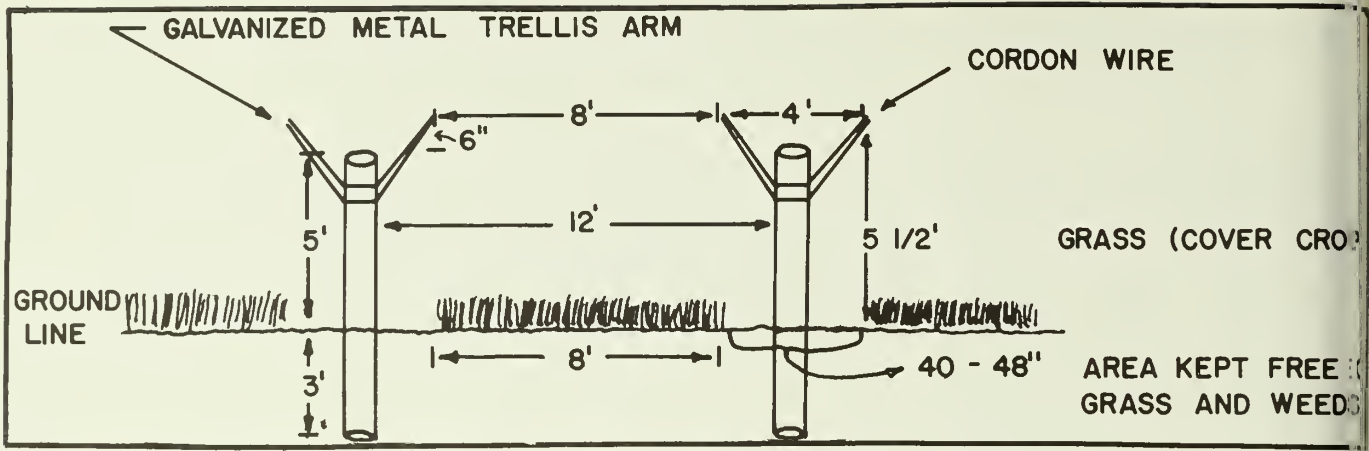


Figure 5. Horizontal and vertical dimensions of a vineyard designed for the preferred "Geneva Double Curtain" trell

Setting Vines[1]

Set vines in late winter (February or March). Most nursery plants are dormant, bare root and packed for shipment in moist peat moss or other materials. If vines cannot be set promptly, store them in a cool place (35-40° F) or heel them in, using a good moist sandy loam soil or a good potting mix. (*Never let roots dry or freeze.*)

Pruning may be necessary before planting---If the root mass is more than 12-15 inches long, cut it back so that roots do not have to be packed or folded in the hole.

Spread the roots and never plant more than 12 inches deep.

Dig the hole large enough that the first new root growth will be in soil used to fill the hole.

Plant vines so that the soil line is 4 to 6 inches above the origin of the first root and prune the above-ground part of the stem to three to four buds (Figure 6).

If planting is delayed until vines have started to grow or if weather and soil conditions are conducive to growth, water the vines during or immediately after planting. *Never let new transplants stand in dry soil after spring weather is conducive to growth.* Irrigate during dry springs and summers to assure vine survival, especially in the first year after transplanting.

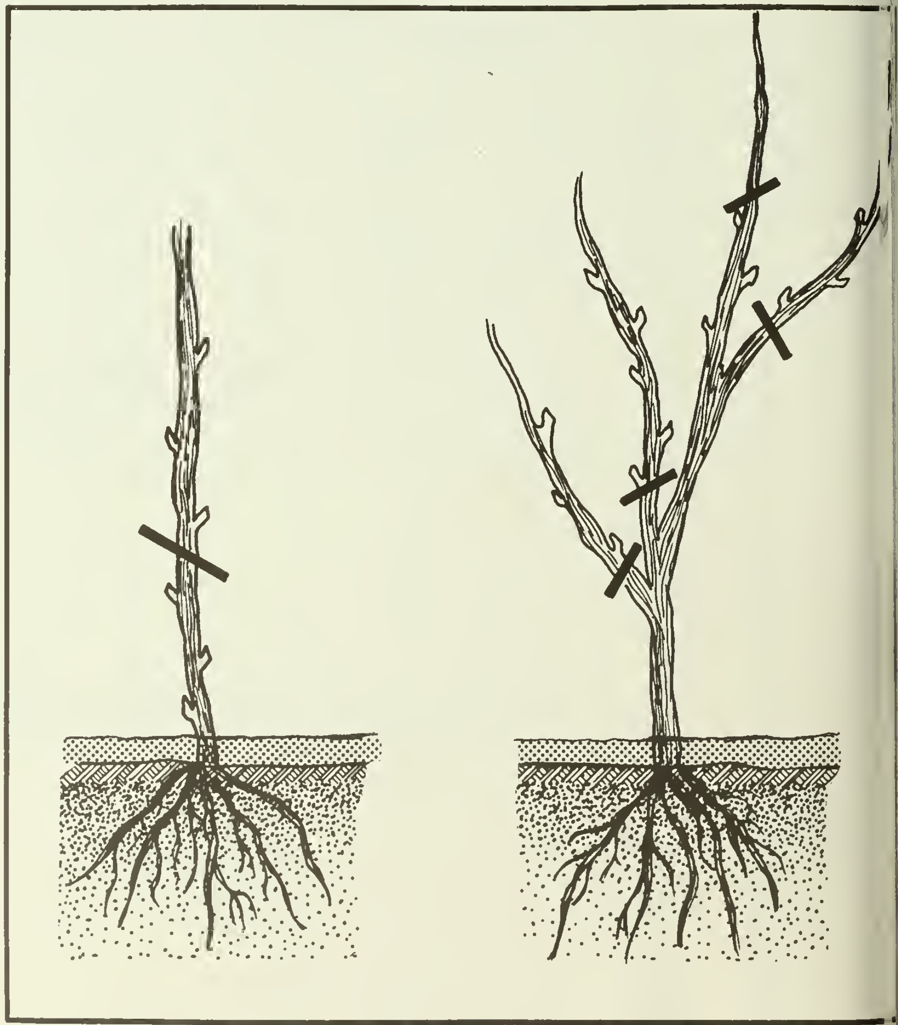


Figure 6. Single-stem, bare-rooted or potted vine pruned to leave three buds (and multi-stem, bare-rooted or potted vine pruned to leave three buds (right) single stem

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[1] Two-year old bare-root or one-year old vines in containers are preferred.

raining Vines

When a newly planted vine breaks rmancy, shoots may emerge from e three or four buds left after uning. Choose one shoot to form e vine trunk and remove all others igure 7). As this shoot develops, ovide some type of vertical pport. This can be done by train- g the shoot up the trellis post if e vine is planted at or near the st. If the vine is planted between e trellis posts, support it with a ake or string. A vertical support akes vine training easier and cilitates the development of a aight trunk. Straight trunks are eferred because they are less likely be damaged by passing equip- ent.

As the trunk-forming shoot grows, ds will develop in the leaf axils d produce third-order branches or laterals. Remove these to promote faster growth of the trunk shoot (Figure 8).

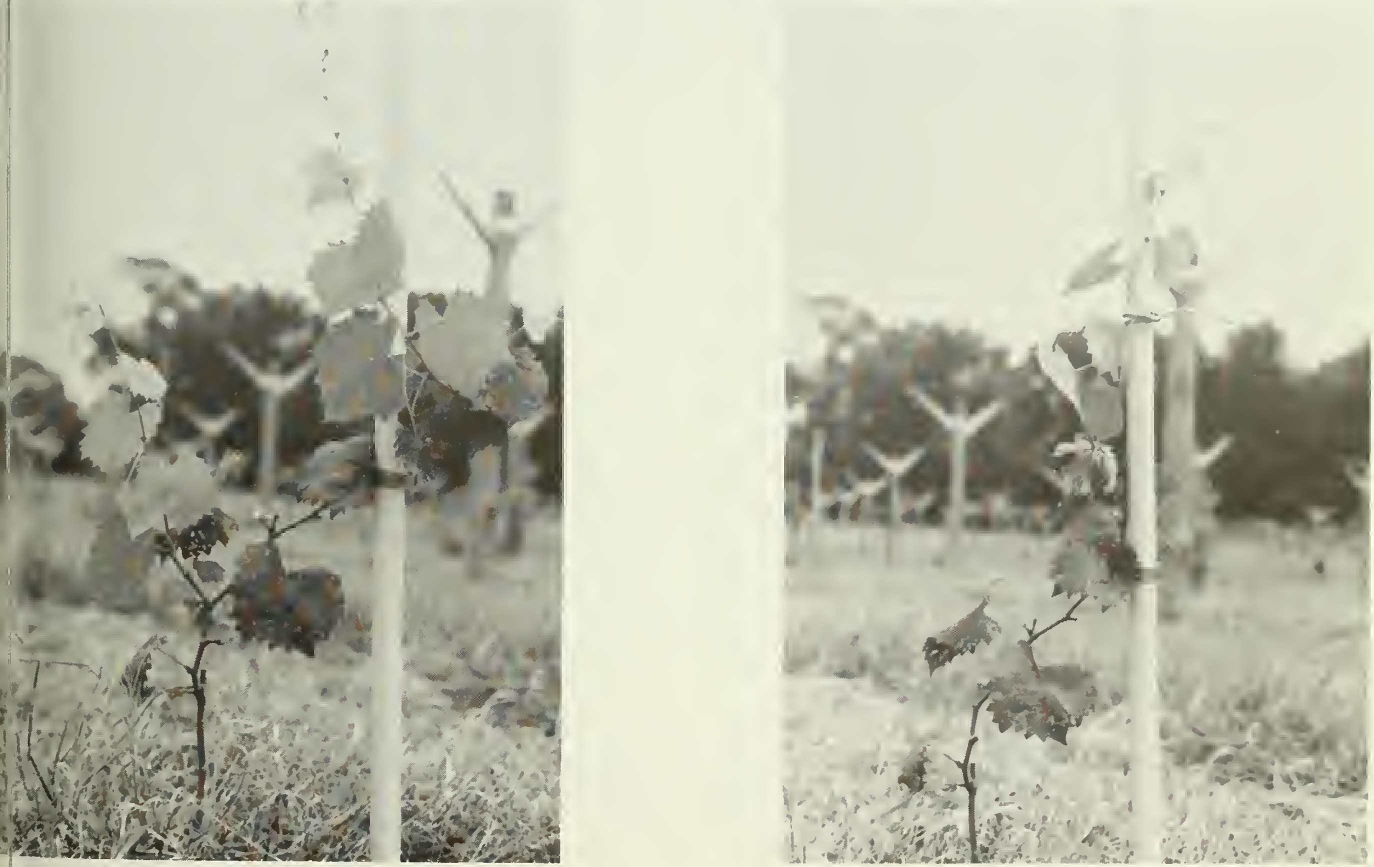
"Geneva Double Curtain"

When the trunk-shoot tip reaches the bottom of the trellis arm or 18-24 inches below the trellis wires (Figure 9), pinch it to force branching. The point of pinching is particularly important for muscadines that are to be harvested mechanically, because the vine trunk may be split by the harvester if the vine is pinched too high. The first branching point must not be above the pivotal point of the trellis arm.

Pinching forces shoots to grow from the buds in the leaf axils just below the pinch. Select two shoots to grow up to the trellis wires (cordon wires). When this growth stage is reached (Figure 10), pinch the shoots 2 to 3 inches below the wires to force growth of lateral shoots. Select four shoots and train them along the trellis wires to a distance of 10 ft from the head of the vine. This development is hastened by preventing lateral shoot growth (Figure 11).

Check the developing vines once each month or, preferably, twice each month and perform needed pruning and tying-training operations (Figure 12). Pinch each shoot when it reaches 10 ft in length (usually in the second year) to form the four cordon arms, which account for all future growth. Restrict all further lateral growth to the four cordon arms and let them grow to the fullest extent.

Maintaining balance in vine development is essential---the two



igure 7. A three-bud, single-stem vine after the first few weeks of growth, before pruning for trunk-shoot selection (left) d after pruning for trunk-shoot selection (right)

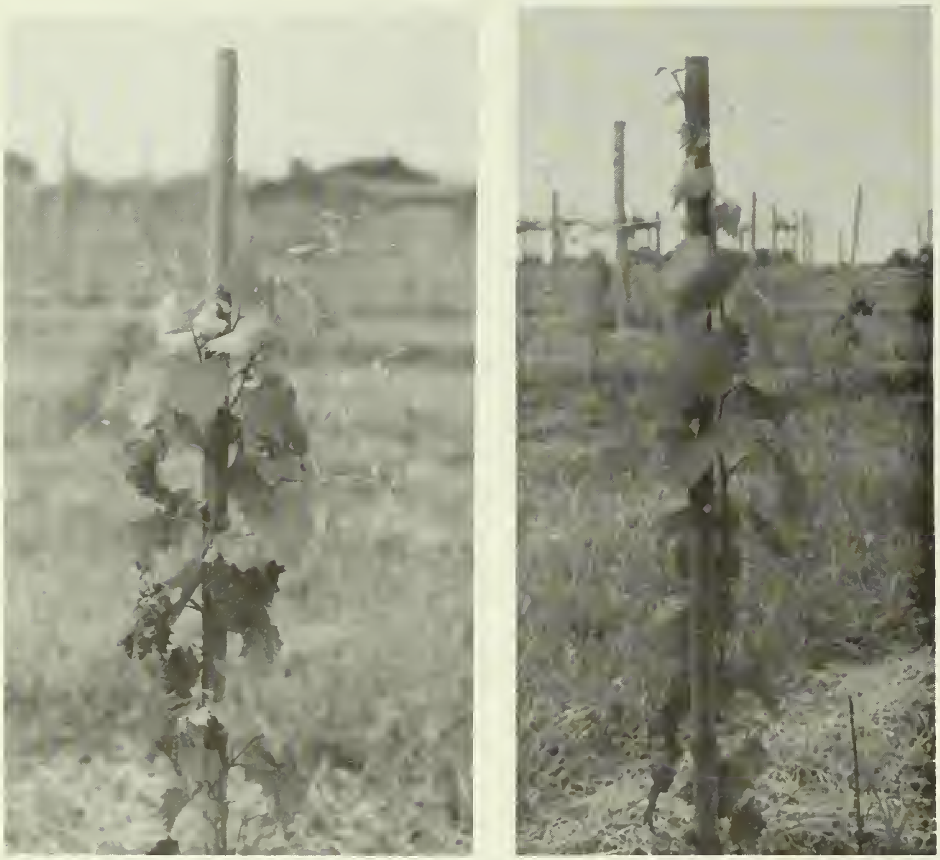


Figure 8. Third-order laterals or branches on the trunk shoot, before pruning (left) and after pruning (right)

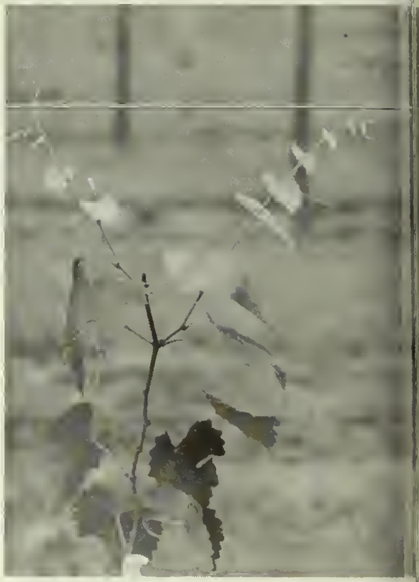


Figure 9. Trunk shoot pinched 18 t
inches below trellis wires

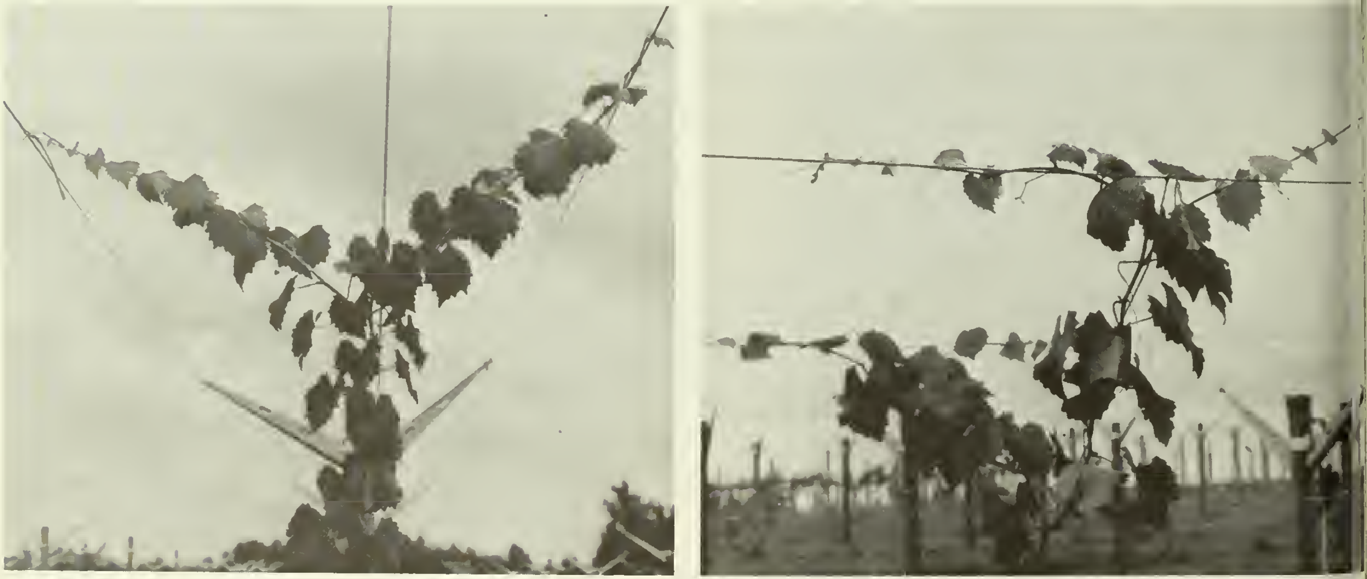
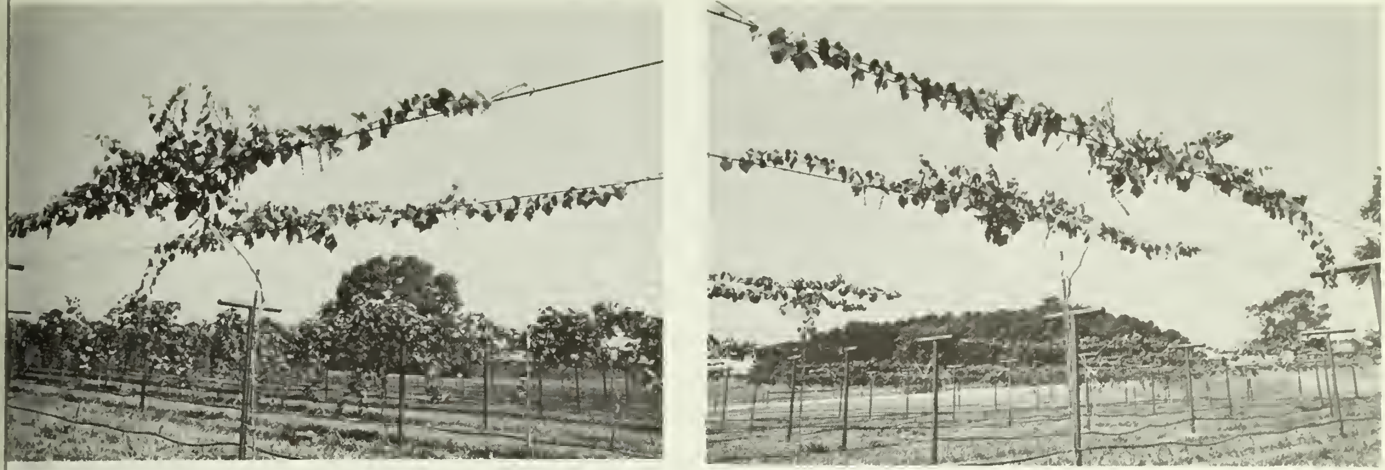
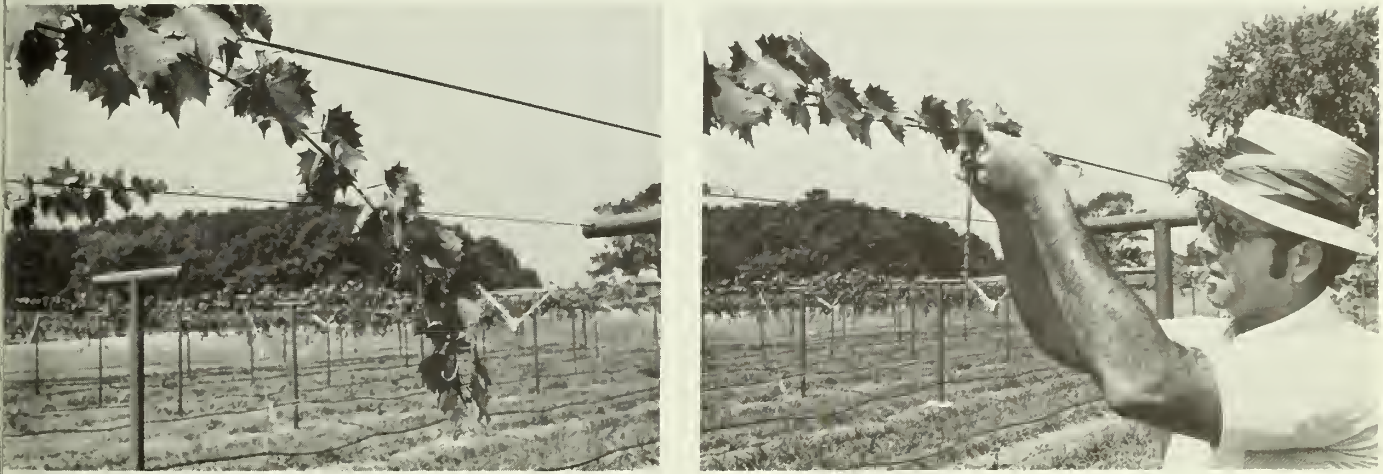


Figure 10. Shoots growing to the trellis wires before pinching (left) and cordon shoots starting down the trellis wire
after pinching (right)



igure 11. Lateral shoot growth on the cordon arm before pruning (left) and after pruning (right)



igure 12. Cordon arm before tying (left) and being tied to the trellis wire (right)

hoots that form the head of the ine and the four cordon shoots hould develop with equal vigor. If rowth of any shoot exhibits domiance, pinch it and select another teral shoot to continue the developent process.

ingle curtain or two-wire vertical rellis

Let the trunk shoot grow past the wer trellis wire to the upper trellis ire (or the top of the post) and inch it. Select four lateral shoots--- wo at the bottom wire and two at the top wire---and train them along the wires as described for the "Geneva Double Curtain".

Tying

When shoots are growing up a post, stake, string or along a trellis wire, tie them as they grow. Several available materials work well; e.g., plastic tape fastened with staples, plastic interlocking ties, natural and synthetic string and plastic interlocking chains (Ag-ties®). The interlocking plastic chain (Figure 13) is popular.

Regardless of type of material, a tie should not be tight enough to girdle the vine. Loosen or remove and replace ties that get too tight.

Summer Training Precautions

Do not cut unwanted shoots at their point of origin when pruning to hasten growth and development of the cordon shoots *because this results in a spurless, non-fruitful cordon arm.* Leave a spur with four or five leaves to promote development of fruiting wood.

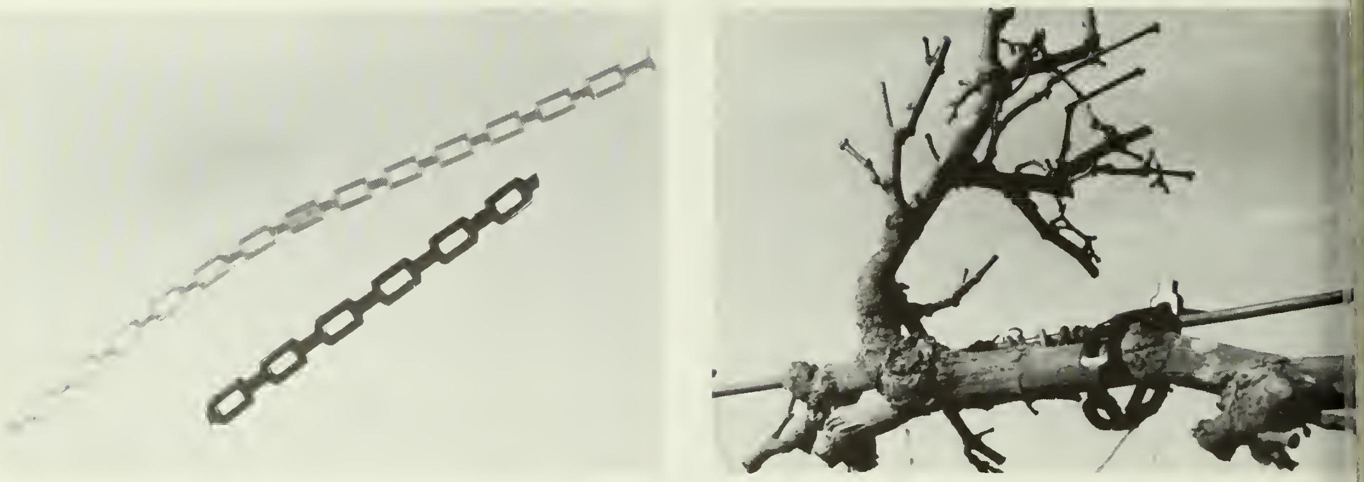


Figure 13. Typical interlocking plastic chains (left) and a plastic chain holding cordon arm to trellis wire (right)

Vineyard Management

Machinery Needs

A tractor, a trail mower and spray equipment are mandatory. Maximum usable space for a tractor between 12-ft wide rows in a vineyard trained to the "Geneva Double Curtain" is 8 ft (Figure 5). A conventional 25-horsepower (HP) tractor is satisfactory for all maintenance operations except mowing the 8-ft middle in one pass, which requires a 50-55 HP tractor that is too wide to pass safely between the rows.

One way to overcome this dilemma is to widen the row spacing, but this results in fewer vines and lower yields from a vineyard of a given size. A second approach is to use a conventional 25-HP tractor and make two passes over each middle with a smaller mower. An alternative is to acquire a narrow, low-profile tractor with enough horsepower to perform all establishment and maintenance operations, but they carry a heavy price tag.

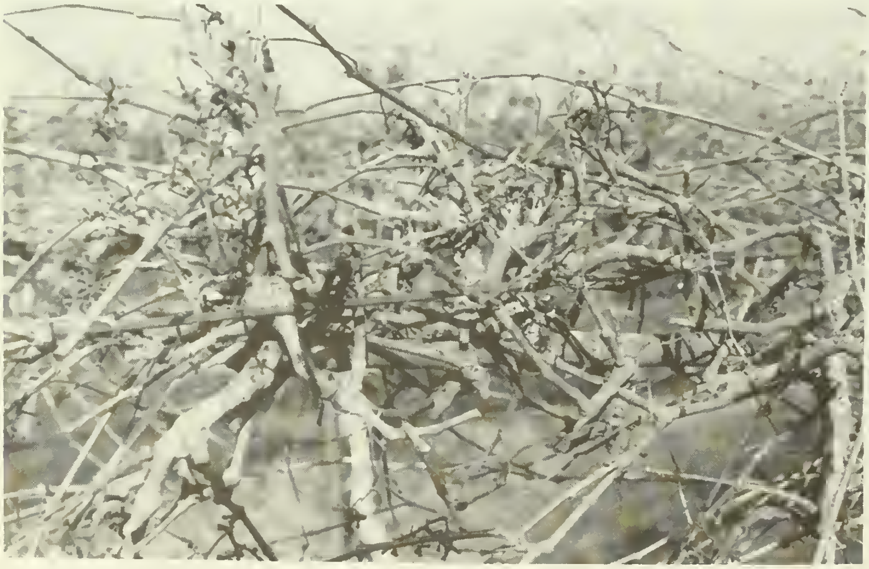


Figure 14. A typical tangled mass that results from lack of pruning or improper pruning

Pruning

An unpruned muscadine vi (Figure 14) eventually becomes mass of tangled, unproductive a diseased growth that is impossil to manage and is hard to harvest. vine that is fully established a trained to a trellis system requir annual pruning, usually in Janua February or March, to mainta the basic form. Other objectives pruning include removal of dea damaged or otherwise undesirab wood. Pruning also regulates veget tive growth and improves t quality and quantity of the crop.

Pruning consists of three di tinctly different operations---(pruning last season's growth (on year old wood) to fruiting spurs; (spur thinning (i.e., removing par of some spurs and, in som instances, all of others to lesse crowding and (3) removal of tendri to prevent girdling.

Removal of last season's growth

A short spur(Figure 15) is on with two or three buds, and a lon spur is one with four to 10 buds Varieties that exhibit low vigor (e.g. Fry and Magoon) generally shoul be pruned to short spurs. Unirrigat e vineyards on poor sites also sould be pruned to short spurs. rieties that exhibit high vigor (g., Carlos and Regale) and irigated vineyards on good sites ay be pruned to long spurs.

Theoretically, vines with longer surs (canes) yield more, but they ust have the inherent capacity f supporting the increased shoot gowth that results from leaving te spurs longer. They also must be gowing in good soils with high ftility and must never be subjected t drought stress.

Significant yield increases have ben obtained in the research plots athe Vegetable Unit of the MAFES Suth Mississippi Branch by prunig vigorous vines to canes with six t eight buds. Cane-pruned vines hve been more difficult to manage, prticularly pruning and harvestig, because of excessive shoot gowth. However, yields following cne pruning have been 25% higher tan yields following spur pruning.

ur Thinning

Spur size is compounded with ech annual pruning, and the corns begin to get crowded after four five years of production (Figure 1). Gradual thinning each year ter the third bearing season will nimize yield reductions caused the removal of spur wood.

moval of *Tendrils*

Tendrils are hard to cut, and a sarp knife is the best instrument the job. They also are hard to see igure 17), and care should be ken to assure that they are not erlooked.

The three pruning operations ould be done sequentially; i.e., une to the desired spur length rst and then thin the spurs before moving the tendrils.

ertilization

Follow the fertilizer recommendans included in the results of the il test made to determine liming quirements of the vineyard site. ring the first two years of vinerd development, apply part of the fertilizer soon after growth starts in the spring, with additional small applications each fifth or sixth week thereafter. More frequent applications are necessary on sandy soils and in years when seasonal rainfall is above average. *Do not apply fertilizer after the first of July.*

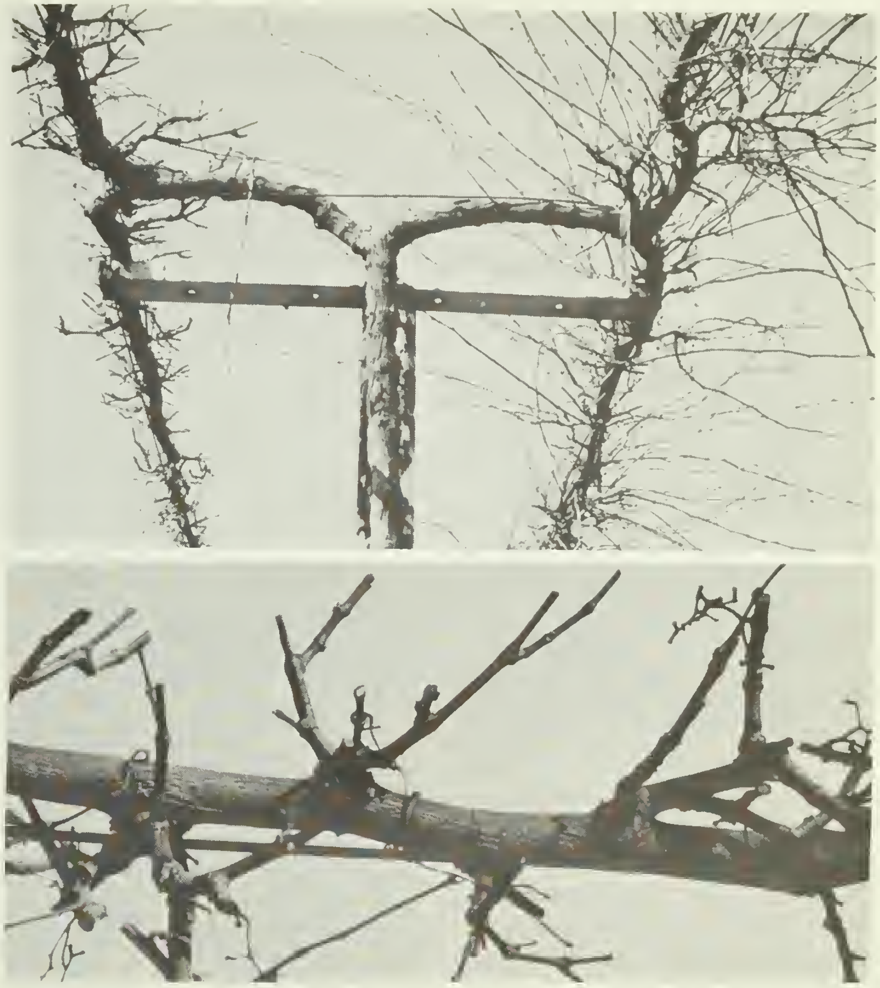


Figure 15. (Top) A cordon arm before pruning (right) and after pruning to short spurs (left). (Bottom) Close-up of short spurs

Monitor the nutritional status of producing vineyards. Take soil and tissue samples and have them analyzed for determination of fertilizer requirements.

Take soil samples in the fall and be sure to request a test for magnesium. Tissue samples should be taken in June and should consist of at least 100 petioles (the part of the leaf that attaches the leaf blade to the shoot). Take only basal leaves on fruiting shoots, preferably those opposite fruit clusters. Do not sample end vines, vines on outside rows or shaded vines. Sample each variety separately. The County Agricultural Agent or Cooperative Extension Service Specialist can provide assistance.

Mature vineyards on most soils should be fertilized only once, in late winter or before initiation of growth in early spring. Very sandy soils are an exception and should receive two applications----one before initiation of growth in the spring, the other about June 1.

The nutrient/water requirements of a producing vineyard diminish as the season progresses. Nutrient and water requirements are highest from bud break to flowering (about June 1) to support vigorous growth and development of the vine, shoots

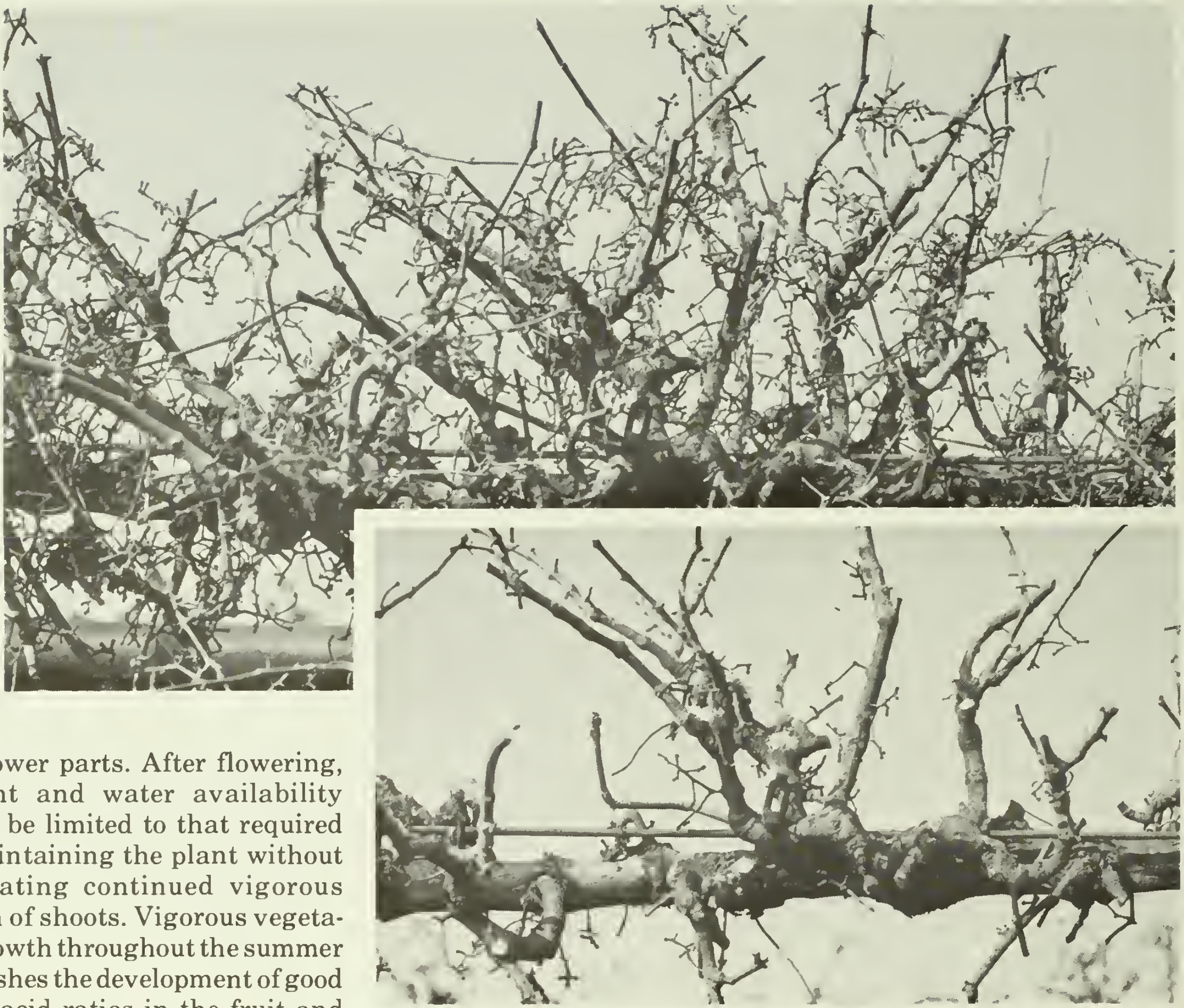


Figure 16. Crowded short spurs after four or five years of production (top) and after spur thinning (bottom)

and flower parts. After flowering, nutrient and water availability should be limited to that required for maintaining the plant without stimulating continued vigorous growth of shoots. Vigorous vegetative growth throughout the summer diminishes the development of good sugar/acid ratios in the fruit and can lead to undesirable hardening of shoots.

Weed Control

A proposed vineyard site with populations of problem perennials (e.g., bermudagrass, johnsongrass and/or nut sedge) should be fallowed for one growing season and treated several times with an effective herbicide. Weed problems during the first growing season can be lessened by the application of herbicides before the vines are set. A combination of shallow cultivation and herbicides usually is necessary for control of weeds in the first two years after the vines are set. Weed control after the first two years usually can be accomplished with herbicides. The County Agricultural Agent or Cooperative Extension

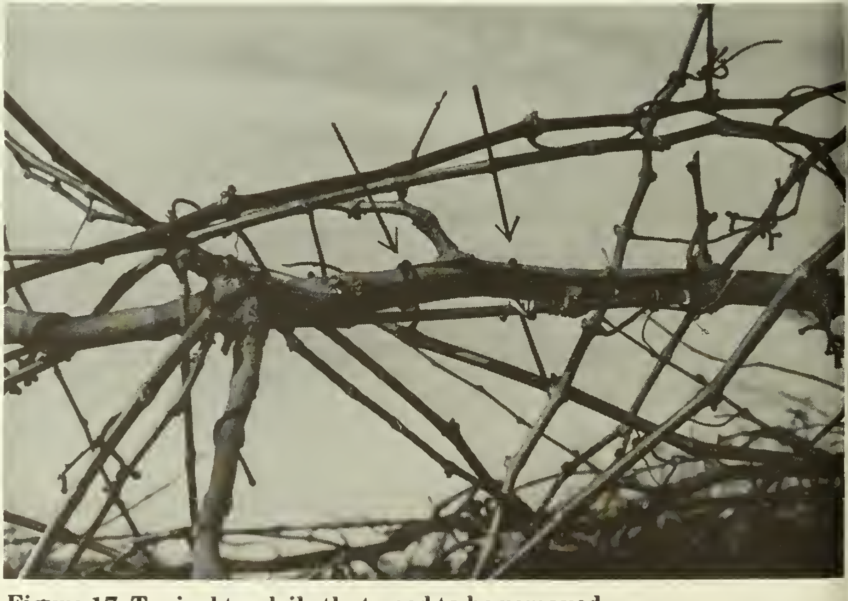


Figure 17. Typical tendrils that need to be removed

rvice Specialist can assist in the velopment of a herbicide program.

Muscadine production is not ndered by a permanent sod growg between the rows if the sod is owed frequently and the area neath the trellis is maintained e of grasses and weeds. The clean ea under the trellis should be 40 48 inches wide (Figure 5).

isease Control

Diseases on muscadines seldom ere a problem in the past; however, th the introduction of new rieties and intensified plantings, me diseases have become so rious that a disease-control proam is essential to the production high yields of quality berries.

runing

Disease spots on canes serve as erwintering sites for fungi. Be re to remove all canes that have sease spots.

raying

Proper application of chemicals r disease control is necessary for ccessful production. *Thorough overage of leaves, berries and ems is important.* The amount of ater needed for adequate coverge of vines varies. Some dilute rayers may use more than 100-00 gal/acre, but low-volume equipent may apply only 20 gal/acre. ir-blast sprayers may be used for w-volume application; however, a actor-mounted, high-pressure rayer[2] (300-400 psi) also may be sed.

Apply the first fungicide spray just before bloom, the second just after bloom. Continue spraying at two-week intervals, until early August for early-ripening varieties and mid-August for late-ripening varieties.

Use mancozeb (Manzate 200® or Dithane M 45®) at 3 lbs/acre until July 1 and use a tank-mix of Captan® 50 WP (3 lbs/acre) and Benlate® (1 lb/acre) thereafter. *Do not use mancozeb within 66 days or Benlate within seven days of harvest.* There is no waiting period for Captan.

Insect Control

Scout the vineyard carefully for signs of damage. Identify the pest and add an appropriate insecticide to the fungicide spray.

Look for the grape berry moth and leaf-feeding insects at the prebloom stage. Nuisance pests that can cause problems during pruning and harvesting are fire ants, bees and wasps. Eliminate fire ants by chemical treatment of the mounds. If a problem with bees and/or wasps is anticipated at harvest, add Sevin® or malathion to the pre-harvest fungicide spray.

Harvesting For Fresh Market

The key determinants of harvesting for fresh market are flavor and attractiveness. Fruit of high quality can be obtained with hand harvesting, and the prolonged ripening of berries permits harvesting of top-quality berries over a longer period. If a large acreage or time constraints make once-over harvesting necessary, some fruit will not be at the optimum stage of maturity.

Grapes for the fresh market should be refrigerated at 35-40° F immediately after harvesting. Proper refrigeration can maintain berry quality for up to 14 days.

Harvesting For Processing

Monitor the maturity status of the berries. Maturity stage is determined by taking a sample of berries from the vineyard and analyzing the juice for pH, total acidity and Brix. Sample each variety separately.

Collect one cluster from each 10th vine of each variety. The cluster collected from each vine should be from different positions as sampling proceeds. Never sample end vines, vines on outside rows or vines near trees.

Crush the sample berries by hand or mechanically. Collect the free-run juice and filter it through several layers of cheesecloth. Analyze the juice for pH, total acidity and Brix, using the techniques outlined by R. P. Vine.[3]

Harvest when juice pH reaches 3.2. At this pH, total acidity values for most varieties range from 0.3 to 0.5. Check with the processor and harvest when delivery can be accepted. If the processor is more than one or two hours from the vineyard and the berries cannot be transported in a refrigerated vehicle, time the harvest so that the berries can be transported after sunset.

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[2] Details for construction of a sprayer of this type are available by writing and requesting two publications---Plan no. 2178 and Folder 299, Vertical Trellis Grape Sprayer. Address correspondence to Biological and Agricultural Engineering Extension, N. C. State University, Raleigh, NC 37607.

[3] Vine, R. P., Commercial Winemaking Processing and Controls

Catch-frame harvesting[4]

Catch-frame harvesting is practical in vineyards that are too small to justify the investment in a mechanical harvester, and frames have been designed for muscadines grown on the "Geneva Double Curtain" or the two-wire vertical trellis.

The catch frames fit under vines and collect the berries as they fall (Figure 18). Berries usually are shaken from the vine by striking the trellis wire with a padded club, and the catch frame funnels them into a suitable container (perforated plastic containers are used in MAFES vineyards). Catch-frame harvesting requires from three to five people for maximum efficiency. Average time required for one vine ranges from 3 to 7 minutes.

Machine Harvesting

Several mechanical harvesters (Figure 19) are adaptable for harvesting muscadines grown on the "Geneva Double Curtain" or the two-wire vertical trellis and accomplish the harvest without excessive berry damage. However, these harvesters are very expensive and are practical only for large vineyards.

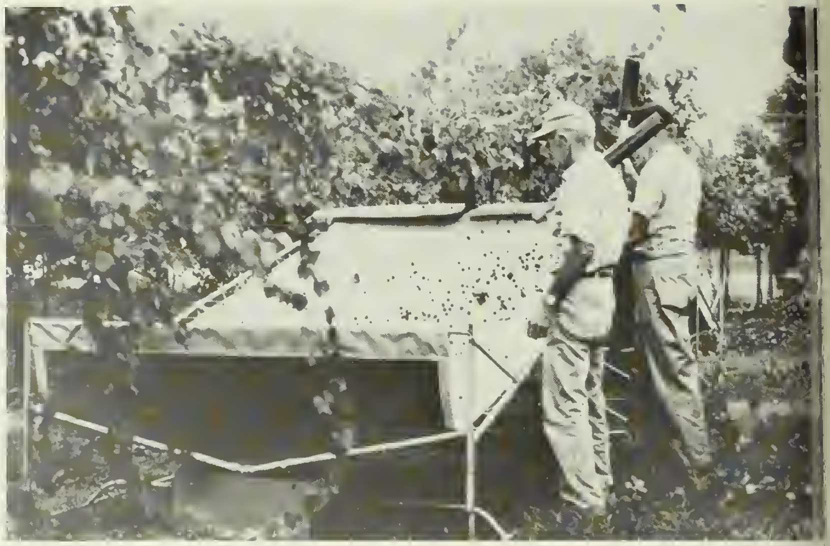

Figure 18. Catch-frame being used to harvest berries from a vi growing on the"Geneva Double Curtain"

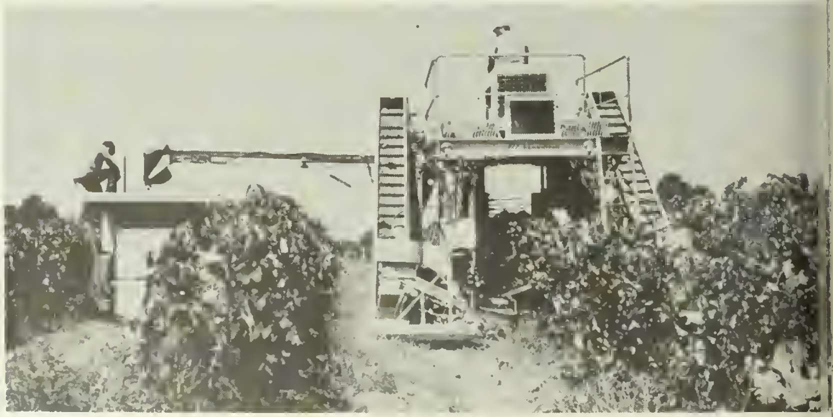

Figure 19. This mechanical harvester shown harvesting bunch grape growing on a two-wire, vertical trellis can be used for harvestin muscadines grown on a two-wire vertical trellis and can be adapted fo harvesting muscadines grown on the "Geneva Double Curtain".

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[4] For details of the harvesting catch frames, see MAFES Information Sheet 1306, Catch Frames for Harvesting Muscadines.

Appendix

Vineyard Site

Soils of light to heavy texture are suitable, *but only if they have good internal drainage.* Loam to sandy loam soil with about 40% sand, 40% silt and 20% clay is preferable, medium fertility is desirable, and pH of 5.8 to 7.0 is desirable.

Preferred row orientation is north to south. However, topography of the vineyard site may not permit this, and the rows may have to be contoured. If the slope of the vineyard site mandates contouring, seek assistance from the Soil Conservation Service. The contour of the vineyard site is the primary determinant of the trellis type that is best suited. Contact a Cooperative Extension Service Specialist for assistance.

Trellising

Trellises for home plantings may be a fence or, if aesthetics dictate, may be many types of decorative arbors. Several types of trellises are suitable for commercial vineyards, but only two types are presented in this guide---both of which are suitable for home or commercial plantings and permit machine harvesting. Costs of construction and yields differ significantly for the two.

The trellis best suited for commercial vineyards is the "Geneva Double Curtain", which is well suited for production of maximum yields and for mechanical harvest. Preferred construction is with No. 9 galvanized wire (or U. S. Steel high-tensile No. 12 wire) and galvanized metal arms (Figure 20).

Vines trained to a double-wire vertical trellis (Figure 21) can be harvested mechanically, but yields are lower than on a double-wire horizontal trellis---the upper cordon shades the lower cordon, and this retards growth of the lower cordon. The main advantages of vertical trellises are simplicity and lower initial cost.

End-post bracing is an important feature of any trellis---no trellis holds up well unless the end posts are anchored or braced properly, and good end-post bracing will save many hours of trellis maintenance. Three end-post bracing designs that work well for trellis systems are illustrated in Figure 22. The design shown in Figure 22c should not be used for rows longer than 250 ft.

Trellis (or cordon) wires should be attached to the end posts to permit tension adjustment as needed. This can be done in several ways---turnbuckles, threaded eye bolts and wire vices (Figure 20) are three devices that work well.

Trellis materials

The most widely used material for posts is treated pine (4″ top diameter). A good non-toxic wood preservative is copper chromium arsenate (CCA). Pentachlorophenol (penta) is another good preservative, but vines should not be permitted to contact freshly treated posts.

All wood materials used in trellis construction should be pressure treated according to the American Wood Preservative Association's (AWPA) standard C16. Wood materials so treated will last 20-25 years.

Trellis longevity is important because vines that are cared for

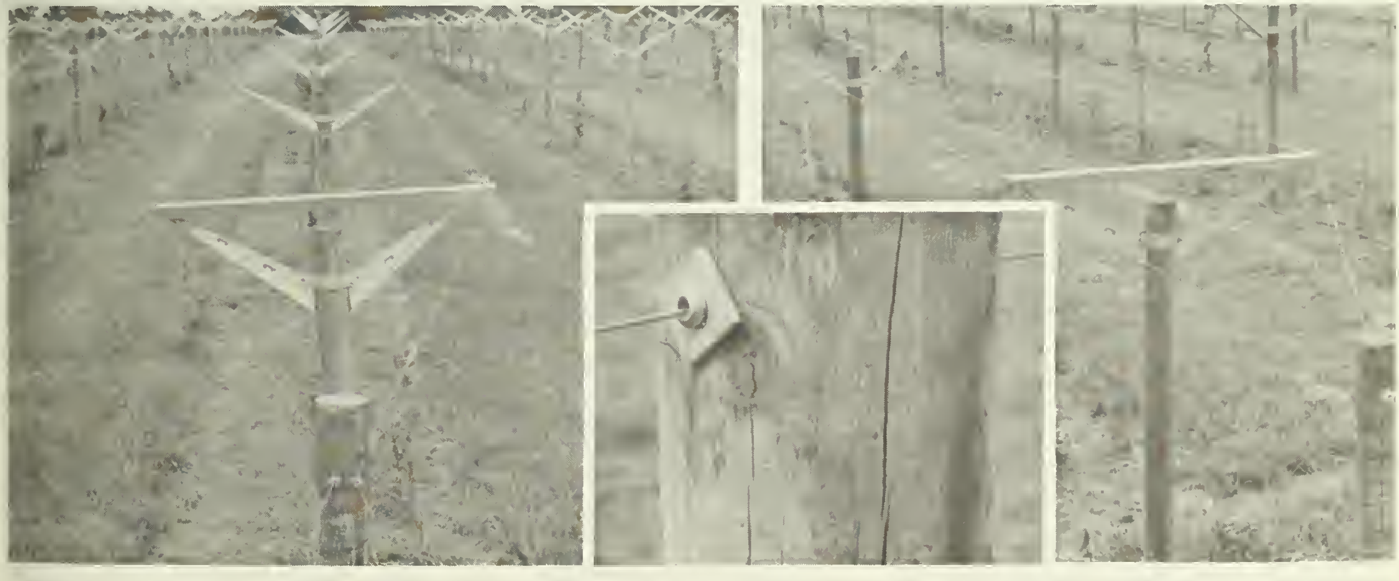

Figure 20. Two views of the preferred "Geneva Double Curtain" trellis constructed with U.S. Steel high-tensile No. 12 wire, Wolverine® galvanized metal arms, treated wood spacers, pressure-treated pine posts and wire vises, with close-up view of a wire vise (insert)

properly are capable of outlasting a trellis, and replacing a trellis in a mature vineyard is a formidable job. This is one reason why U. S. Steel high-tensile No. 12 wire is used in new MAFES vineyards.

Varieties

Muscadine varieties have been tested by the Mississippi Agricultural and Forestry Experiment Station (MAFES) since 1973 to determine their suitability for wine, non-fermented products and fresh markets (roadside and pick-your-own) in Mississippi. Tests have been located at four MAFES Branch Stations---South Mississippi Branch Fruit and Vegetable Unit at Beaumont, Truck Crops Branch at Crystal Springs, Delta Branch at Stoneville and Northeast Mississippi Branch at Verona. A younger vineyard at Mississippi State University is now producing.

Several muscadine breeder's selections from the North Carolina and Georgia Agricultural Experiment Stations have been tested in addition to named varieties. Two of the more promising North Carolina selections recently were released jointly by MAFES and the North Carolina Agricultural Research Service as Regale and Doreen.

Regale is self-fertile, black-fruited and heavy-producing. It exhibited good cold tolerance in areas approaching the northern limit for muscadines. It is resistant or tolerant to some diseases, and other diseases may be controlled by regular fungicide applications. The ripening season in Mississippi has been early to mid-September. Berries are larger than berries of Noble, a prominent black-fruited variety.

Regale has produced as large or larger crops than other black-fruited varieties. Regale produced 2.8 tons/acre/year more than any other variety at one branch station.

The most important use of Regale may be as a companion variety for Noble. Many good red wines are blends of two or more red varieties.

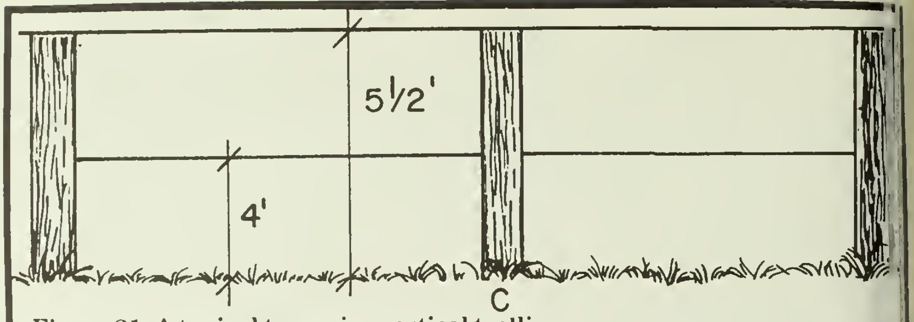

Figure 21. A typical two-wire vertical trellis

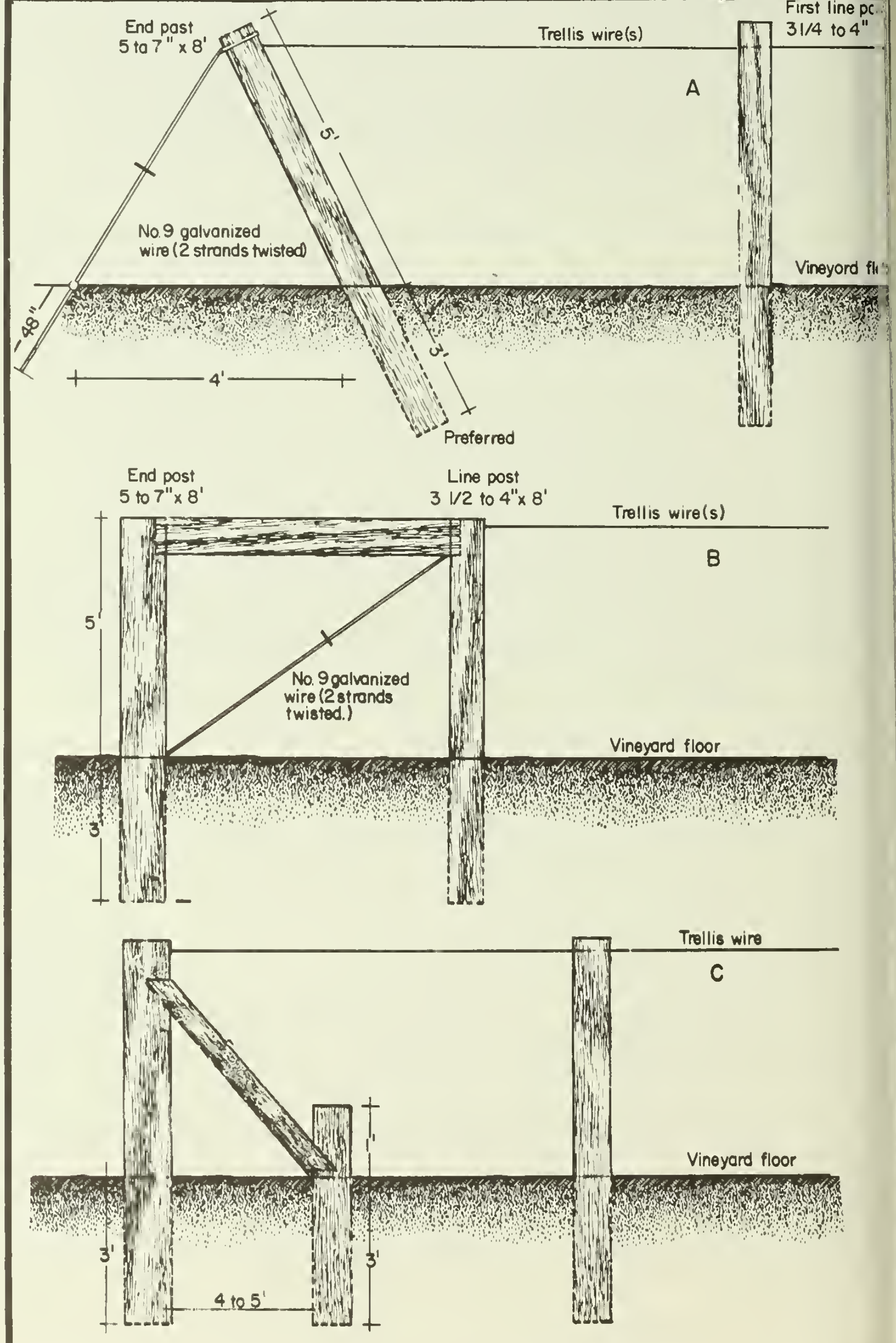
End post
5 to 7" x 8'
Trellis wire(s)
First line po
31/4 to 4"
A
5'
No.9 galvanized
wire (2 strands twisted)
Vineyard fl
48"
4'
3'
Preferred
End post
5 to 7"x 8'
Line post
3 1/2 to 4"x 8'
Trellis wire(s)
B
5'
No. 9 galvanized
wire (2 strands
twisted.)
Vineyard floor
3'
Trellis wire
C
1'
Vineyard floor
3'
3'
4 to 5'

Figure 22. Three recommended end-post bracing designs.

egale has been tested as a varietal ed wine for seven years at North arolina State University. Taste anelists have rated it average to ood in overall wine quality but oted a less intense color than for oble and Tarheel.

Doreen is self-fertile, bronze-ruited and highly productive. It ipens in late September, about three eeks after Regale, Noble, Carlos nd Magnolia. It separates readily rom the vine with a minimum of erries with torn skin. The flavor is leasant, fruity and sweet and ypical of muscadines.

Doreen yields generally have been xcellent and have been better than ields of other varieties tested at eaumont. Plot yields at Beaumont onvert to 20.4 tons/acre in 1978 fourth fruiting year), no crop in 979 (Hurricane Frederick destroyed rop), 21.9 tons/acre in 1980, 22.4 ons/acre in 1981 and 18.6 tons/acre n 1982. In commercial muscadine-roducing areas, 5 to 10 tons/acre re considered very good yields.

Doreen fruit can be made into a ight golden wine equal in quality o that from the best bronze cultivars, and Doreen wines have been udged above average. Doreen can be used to extend the harvest and rush season for white muscadines in areas where it ripens uniformly.

Other muscadines that appear to be best for white wines are Carlos, Magnolia, Sterling, Nevermiss and Summit (a pistillate variety). Making good red wines from muscadines is difficult because of pigment instability, but very good wines have been made from Noble and Tarheel under carefully controlled conditions.

The quality for fresh market, "pick-your-own" and local sales of varieties evaluated since 1973 is acceptable except for Pride. The best varieties for storage or shipment to distant markets are Carlos and Southland. Large-fruited varieties (e.g., Jumbo, Fry and Higgins) are very good choices for fresh market and "pick-your-own" vineyards. Watergate and Sugargate have potential for the fresh market, because their berries are very large, skins are thinner and flavors are different from Jumbo. However, Watergate and Sugargate have pistillate flowers and require pollinators, and Sugargate has been notorious for poor yields in Mississippi.

Some characteristics of muscadine varieties that have been studied in Mississippi (Table 1), their yields (Tables 2, 3 and 4), sugar content of their juice (Tables 5 and 6) and size of their berries (Tables 7 and 8) are presented as a guide to selecting varieties for Mississippi vineyards.

Table 1. Flower type, fruit color, berry size and vine vigor of selected muscadine cultivars.

Cultivar	Flower type[1]	Fruit color	Berry size[2]	Vine vigor
Albemarle	SF	Black	Medium	Medium
Bountiful	SF	Black	Small	Medium
Carlos	SF	Bronze	Medium	High
Chief	SF	Black	Small	Medium
Chowan	SF	Bronze	Medium	High
Cowart	SF	Black	Large	Medium
Creek	P	Black	Small	Medium
Dearing	SF	Bronze	Small	Low
Dulcet	P	Black	Small	Low
Fry	P	Bronze	Large	Low
Higgins	P	Bronze	Large	Medium
Hunt	P	Black	Medium	Very high
Jumbo	P	Black	Very large	Medium
Magnolia	SF	Bronze	Medium	Medium
Magoon	SF	Black	Small	Low
Nevermiss	SF	Bronze	Medium	High
Noble	SF	Black	Small	High
Pamlico	SF	Bronze	Medium	High
Pride	P	Black	Large	Very low
Redgate	SF	Bronze-red	Small	High
Regale	SF	Black	Medium	High
Roanoke	SF	Bronze	Medium	Medium
Scuppernong	P	Bronze	Medium	High
Southland	SF	Black	Medium	Medium
Sterling	SF	Bronze	Medium	Medium
Sugargate	P	Black	Very large	Medium
Summit	SF	Bronze	Large	High
Tarheel	SF	Black	Small	High
Thomas	P	Black	Small	Medium
Watergate	P	Bronze	Very large	Medium
Yuga	P	Bronze	Small	High

[1] SF = Self-fertile
P = Pistillate (female)

[2] Small = 2.1-4.0 gr/berry; Medium = 4.1-6.0 gr/berry;
Large = 6.1-8.0 gr/berry; Very large - 8.1-10.0 gr/berry.

Table 2. Three-year average yields of muscadines in replicated trials (averages of six vines of each cultivar at each location), by cultivar and location.

Cultivar	Vineyard location Beaumont	Crystal Springs	Delta	Average
Carlos	95.6	52.6	86.3	78.1
Cowart	82.2	42.0	82.1	68.8
Creek	91.1	46.1	65.7	67.6
Dearing	42.1	27.5	34.3	35.0
Higgins	97.5	56.7	85.0	79.7
Hunt	71.1	69.4	62.7	67.7
Magnolia	112.6	43.8	90.1	82.2
Noble	101.4	53.7	88.7	81.3
Regale	103.6	62.7	114.6	93.6
Roanoke	78.7	46.2	68.4	64.4
Scuppernong	66.1	45.7	44.7	52.2
Sterling	101.7	35.6	77.9	71.7

Table 3. Three-year average yields of muscadines in observation trials (averages of two vines at each location), by cultivar and location.

Cultivar	Vineyard location Beaumont	Crystal Springs	Delta	Average
Albemarle	44.5	23.5	43.8	37.3
Bountiful	45.8	38.0	63.3	49.0
Chief	46.0	57.0	48.5	50.5
Chowan	19.1	23.7	32.2	25.0
Dulcet	46.4	40.7	49.2	45.5
Fry	101.4	41.7	62.5	68.5
Jumbo	95.6	41.7	99.3	79.9
Magoon	42.9	29.5	40.5	37.6
Nevermiss	60.4	26.3	52.7	46.5
Pamlico	31.8	20.2	24.5	25.5
Pride	52.5	31.8	34.5	39.6
Southland	44.6	32.0	69.2	48.6
Summit	95.4	28.5	85.8	69.9
Tarheel	81.7	44.0	58.8	61.5
Thomas	67.3	42.0	73.3	60.9
Yuga	52.7	46.3	67.2	55.4

Table 4. Yields in the first four production years of the MAFES vineyard at Beaumont (averages of six vines of each cultivar), by cultivar and year.

Cultivar	Production year			
	1978	1977	1976	1975
Carlos	85.7	124.3	109.7	52.6
Cowart	138.4	125.0	93.7	27.9
Creck	120.2	129.4	95.2	45.3
Dearing	77.4	65.5	45.1	15.5
Higgins	188.1	137.9	129.4	25.0
Hunt	111.0	104.0	92.3	17.1
Magnolia	160.3	168.8	129.5	39.4
Noble	143.5	151.3	117.7	34.8
Regale	175.2	148.7	129.3	32.6
Roanoke	112.2	103.0	89.1	43.6
Scuppernong	100.8	95.7	83.0	19.5
Sterling	155.8	149.1	117.1	38.6

Table 5. Percent soluble solids in juice of muscadines from MAFES vineyards (three-year averages of six vines of each cultivar) by location.

Cultivar	Vineyard location				Average
	Beaumont	Crystal Springs	Delta	Verona	
Carlos	15.9	15.1	17.9	15.4	16.1
Cowart	17.7	14.9	17.9	16.6	16.8
Creek	16.9	16.9	19.2	17.9	17.7
Dearing	19.0	17.7	22.9	14.8	18.6
Higgins	16.1	15.1	15.3	17.4	16.0
Hunt	15.2	15.9	18.3	13.6	15.8
Magnolia	15.7	14.8	14.5	16.3	15.3
Noble	18.5	16.4	18.1	16.9	17.5
Regale	15.6	15.2	13.8	14.6	14.8
Roanoke	15.5	15.7	16.2	14.8	15.6
Scuppernong	15.9	14.4	17.3	15.7	15.8
Sterling	16.8	15.8	16.2	15.7	16.1

Table 6. Percent soluble solids in juice of muscadines from MAFES vineyards (three-year averages of two vines of each cultivar) by location.

Cultivar	Vineyard location				Average
	Beaumont	Crystal Springs	Delta	Verona	
Albemarle	18.1	17.7	19.5	18.2	18.4
Bountiful	17.7	16.6	18.6	16.4	17.3
Chief	18.7	19.1	20.8	15.8	18.6
Chowan	17.3	17.5	17.9	18.1	17.7
Dulcet	17.2	17.7	17.6	17.8	17.6
Fry	17.9	17.8	19.4	19.4	18.6
Jumbo	15.6	15.0	16.1	14.1	15.2
Magoon	20.9	19.9	21.5	18.7	20.3
Nevermiss	15.0	14.4	15.1	16.3	15.2
Pamlico	16.5	14.9	18.1	17.0	16.6
Pride	15.2	16.2	15.3	15.3	15.5
Southland	18.3	18.1	19.3	18.3	18.5
Summit	18.7	20.2	17.9	16.0	18.2
Tarheel	17.9	18.3	19.9	18.5	18.7
Thomas	18.9	15.9	19.7	17.0	17.9
Yuga	18.1	18.1	19.5	17.3	18.3

Table 7. Berry weights of muscadines from MAFES vineyards (three-year averages of six vines of each cultivar), by location.

Cultivar	Beaumont	Crystal Springs	Delta	Verona	Average
	gms/berry				
Carlos	4.9	3.9	4.5	5.0	4.6
Cowart	6.8	5.1	5.2	5.8	5.7
Creek	3.0	2.9	2.8	2.8	2.9
Dearing	3.1	3.1	2.9	3.0	3.0
Higgins	7.4	6.1	5.9	6.9	6.6
Hunt	4.6	4.1	4.5	4.3	4.4
Magnolia	5.2	4.9	4.2	4.7	4.8
Noble	3.0	2.9	3.0	2.6	2.9
Regale	4.7	4.7	4.0	4.3	4.4
Roanoke	4.4	4.3	4.4	4.5	4.4
Scuppernong	4.6	3.9	4.3	3.7	4.1
Sterling	5.7	5.2	4.9	5.7	5.4

Table 8. Berry weights of muscadines from MAFES vineyards (three-year averages of two vines of each cultivar), by location.

Cultivar	Beaumont	Crystal Springs	Delta	Verona	Average
Albemarle	5.7	4.8	4.7	4.6	5.0
Bountiful	3.4	3.2	3.3	3.0	3.2
Chief	3.2	3.4	2.8	3.0	3.1
Chowan	5.3	4.0	4.8	3.9	4.5
Dulcet	2.9	2.9	2.7	2.8	2.8
Fry	8.8	7.7	6.3	8.0	7.7
Jumbo	10.5	9.1	8.3	9.3	9.3
Magoon	3.1	3.2	2.8	3.3	3.1
Nevermiss	4.8	4.3	4.3	4.0	4.4
Pamlico	5.4	5.5	5.0	5.3	5.3
Pride	7.3	7.3	4.5	6.6	6.4
Southland	4.3	4.5	4.2	3.2	4.1
Summit	7.3	7.8	6.8	6.9	7.2
Tarheel	2.7	2.5	2.5	2.3	2.5
Thomas	3.3	3.6	3.0	2.5	3.1
Yuga	3.3	3.6	3.4	3.9	3.6

Irrigation

Investment in the establishment of a vineyard without providing a dependable irrigation system is an exercise of poor judgment. Vine losses in the first spring and summer after planting can be reduced by irrigation, and vine growth in the first two to three years can be enhanced by irrigation.

Irrigation in the first two years speeds establishment of uniform and healthy vines, and a first crop from all vines in irrigated vineyards normally is expected in the third year. A vineyard that is not irrigated may require three or more years to obtain a complete stand, and production from all vines is not obtained until the sixth or seventh year.

Irrigation is less important after a vineyard is well established (four years or older) but can increase yields and improve berry quality, especially in dry years. Bearing vineyards should be irrigated to stimulate optimum growth from early spring through mid-July, the period that coincides with flower development, bloom, fruit set and early fruit development.

Vineyards should not be irrigated after the berries begin to ripen because irrigation stimulates growth of vines until first frost and makes them more vulnerable
winter damage and/or winter kil
Vine growth should be permitted
slow naturally so that vines ca
harden properly to withstand winte
temperatures.

First-year irrigation can be don
with a *water trailer*, but this is
time-consuming method.

Trickle irrigation is the mos
efficient method but requires a filte
ing system for muddy water fro
ponds or lakes. Excellent result
have been attained with two in-lin
swimming pool sand filters. Wate
from most wells can be filtere
inexpensively unless it has hig
iron content.

Flood (furrow) irrigation can be sed, but the vineyard must be on nd with a slope that permits water flow freely from the high to the w end of the vineyard.

Sprinkle (overhead) irrigation can e used. However, the investment large, and high operation pressure required to distribute large olumes of water. Another disdvantage of sprinkler systems is e wetting of foliage, which can reate and/or compound disease roblems. Also, an application durng the pollinating period may educe fruit set.

iseases

Black rot (*Guignardia bidwellii*) ppears on berries as dry, black nd scabby spots. It can occur at ny time before maturity but is found most often by the time berries re half grown. Berries of Higgins, Hunt and Scuppernong are especially susceptible.

The disease begins as tiny, reddish-brown spots on the upper surface of leaves. These spots grow to ¼ inch or more in diameter and turn brown with black borders. Small, black, pimple-like fruiting bodies, which contain the fungus spores, develop near the outer edge of the brown area. Sunken, dark cankers occur on new stems.

The fungus overwinters on infected canes and on berries that fall to the ground. Infection occurs on new shoot growth in the spring and spreads to young berries.

Bitter rot (*Melanconium fuligineum*) occurs primarily on berries and pedicels but also can cause tiny, dark flecks on young leaves, stems, blossoms and flower buds. Berries are more susceptible as they approach maturity.

The first sign of disease on the berry is a brownish, water-soaked spot that can resemble insect injury. These spots enlarge and rot the berry as it ripens, causing it to turn black and shrivel.

The fungus can overwinter in stem lesions or can be blown into vineyards. Higgins and Fry are extremely susceptible.

Ripe Rot (*Glomerella cingulata*) is difficult to distinguish from bitter rot without microscopic examination. It may appear a little nearer to harvest than does black rot, and symptoms on berries may be a little darker. Sunken or flat rotten areas appear on the surface of berries. Most of the berry is affected, and only a shriveled black shell is left.

The disease spreads rapidly from berry to berry during wet weather and is much worse when berries are injured by insects or damaged during harvest. Pink or light-brown fungus spore masses may appear on the surface of rotten berries. Higgins and Fry are extremely susceptible.

Cercospora or angular leaf spot (*Mycosphaerella angulata*) affects foliage only. Infection occurs in midseason and later and appears as tiny, brown, angular spots on leaves. If severe, it will cause yellowing and premature dropping of leaves. Severe leaf drop results in small berries with low sugar content.

Macrophoma rot (*Botryosphaeria ribis*) is caused by a wind-borne fungus and occurs on berries near harvest. It appears first as a round, light-brown spot that turns black and is slightly sunken. The black spot becomes surrounded by a greasy, greenish halo. Several spots can run together and make the berry a watery mass of rotten tissue. Hunt and Scuppernong are highly resistant.

Powdery mildew (*Unicinula necator*) occurs on berries in most stages of growth. A grayish and powder-like moldy fungus growth appears on the surface of young berries and reduces their size and quality. Affected berries become russeted and many crack and fall from the vine. Powdery mildew can occur on leaves in late fall but usually does little if any damage.

Insects

Insects found in vineyards are classified into four groups according to the types of damage they do.

Chewing insects make holes in leaves, buds or fruit and include many general feeders (e.g., grasshoppers, cutworms, grape flea beetle, grape berry moth and the adult grape rootworm).

Sucking insects cause yellowish, sickly vines that lack vigor. Nymphs and adults of grape leafhoppers cause these symptoms.

Root insects that damage bunch grapes are the grape rootworm, the grape root borer and the grape phylloxera. The grape rootworm feeds on small roots, and this slows vine growth. The grape root borer feeds in the wood and inner bark near ground level and kills vines. The grape phylloxera causes galls on the roots, and this saps the vines. The only root insect that affects muscadines importantly is the grape root borer.

Mites, thrips, scale and some caterpillars also may injure muscadine vines.

Characteristics That Affect Harvesting

Muscadine clusters are small, usually containing six to 24 berries. Mature berries of most varieties do not adhere to the stems as do those of bunch grapes, and berry fall (shattering) of early ripening berries results in loss of some of the crop.

Berries ripen unevenly because of the long flowering period (early May until mid-June), and the main crop (primary fruit set) is set over a three- to four-week period. Consequently, each cluster may contain flower buds, flowers and small berries at the same time. Also, each shoot has from one to three or more clusters, and the order of blooming of clusters is the one nearest the base of the shoot first, the one next to it second and the one farthest from the base of the shoot last.

Another characteristic that affects harvesting importantly is berry tear (wet stem scars). Berries often tear at the point of attachment to the cluster, and berry maturity affects the amount of tear. Berries that are fully mature when harvested usually fall with a dry stem scar, and many of those harvested before they are fully ripe have wet stem scars.

The percentage of berries with dry stem scars is higher for some varieties (e.g., Carlos and Southland) than for others. If a vineya is being established for fresh mark sales other than "pick-your-ow or roadside stands, planti varieties with the highest perce age of dry stem scars should considered.

Sources of Vines

All vines in the MAFES vineyards were obtained from

South Forest Rose Nursery, Inc.,
Rt. 6, Box 167, Hattiesburg
MS 39401

Southern Orchard, Inc., Rt. 5, Box
73-B, Louisville MS 39339

Owen's Vineyard and Nursery,
Georgia Highway 85, Gay GA 30218

Ison's Nursery and Vineyard,
Brooks GA 30205

Many garden centers, cooperatives and other nurseries in Mississippi now carry vines. Also, two of the four commercial wineries in the state currently are propagating and selling vines.

The County Agent or Cooperative Extension specialist can assist in locating a convenient and reliable source of vines.

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Muscadines for the Home Vineyar Cooperative Extension Servic Mississippi State Univerist MS ST MS 39762

Muscadine Grapes for Profi Cooperative Extension Servic University of Georgia Colleg of Agriculture, Athens GA 306

Muscadine Grape Production f North Carolina, Cooperati Extension Service, Nort Carolina State Universit Raleigh NC 27607

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Hybrid Corn Performance Trials

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HYBRID CORN PERFORMANCE TRIALS IN 1982

Trials are conducted annually in lississippi to provide farmers, seedsmen, county agents and thers with information on the erformance of commercially vailable corn hybrids. Results of he trials are provided for use by orn producers in selecting hybrids uited to their area. New hybrids nay be compared with familiar hybrids.

Corn hybrids respond differently o variations in environment, and a given hybrid is not always the best under all conditions. Therefore, it is suggested that corn producers grow two or more good hybrids each year. This practice also reduces the chances for spread of a disease or insect infestation through the total corn acreage.

The yield of harvestable, good-quality grain (or silage) determines the desirability of corn hybrids. However, attributes other than yield may be extremely important in some instances. For example, resistance to a particular disease should be the prime consideration in areas where the disease occurs. That is, hybrids selected should be from those known to have resistance to diseases found in a geographic area.

All producers and/or distributors of seed corn are eligible to enter hybrids in these tests. Hybrids can be entered for testing in Area 1 (northern Mississippi), Area 2, (southern Mississippi) or both. The producers designate the hybrids they want entered in each area. Hybrids must be submitted for entry to the Mississippi Agricultural and Forestry Experiment Station by February 15. A nominal fee is charged for each hybrid tested in each area to help defray costs of the tests.

Three or more tests were located in each area. Trials were conducted at nine locations in 1982 (Table 1).

The best guide to the desirability of a hybrid is its performance over a period of years at a number of locations. Therefore, three-year summaries are reported for each area.

Materials and Methods

Hybrids were tested at two population levels. The design was a randomized complete block with three replications. All tests were overplanted and later thinned to 16,000 or 22,000 plants per acre, stand permitting. Each plot consisted of two rows, 38 inches apart and 200 inches long. Fertilizer was applied by each cooperator as he thought necessary, and weeds were controlled by cultivation and herbicides.

All tests were harvested with a mechanical picker-sheller. Grain harvested from each plot was weighed, and moisture content was determined. All weights were converted to bushels per acre at 15.5% moisture.

Results and Discussion

Area 1

Amounts and distribution of rainfall in 1982 were good at the six ocations. The test at Brooksville was not harvested because stands were poor, and the stand problem was compounded by chinch bug damage.

Average yields of the hybrids tested at 16,000 plants/acre were 109, 99, 118, 135 and 136 bu/acre at Holly Springs, Pontotoc, Verona, Stoneville and Mississippi State, respectively. Yields averaged over all locations ranged from 76 to 143 bu/acre, with a mean of 119 bu/acre (Table 2). Time from planting to mid-silk ranged from 74 to 91 days and averaged 80 days (data from Mississippi State with planting on March 24).

Differences in the performance of the hybrids tested at Holly Springs and Verona could not be determined because of field variations; therefore, results at this plant population are summarized for only three locations (Table 3). As normally can be expected under better growing conditions, yields averaged over the three locations were higher (137 bu/acre) at the higher plant population than at 16,000 plants/acre (123 bu/acre).

Average yields of all hybrids tested at 22,000 plants/acre were 101, 147 and 163 bu/acre at Pontotoc, Stoneville and Mississippi State, respectively. Yields averaged over the three locations ranged from 94 to 164 bu/acre (Table 3).

Root and stalk lodging in the trials at 22,000 plants/acre was not serious at any location. Time from planting to mid-silk at Mississippi State ranged from 75 to 91 days and averaged 81 days. Therefore, maturity from growing 22,000 plants/acre (as measured by days to mid-silk) was one day later than growing 16,000 plants/acre.

Average yields of the 22 hybrids that have been tested at 16,000 plants/acre for the last three years ranged from 89 to 108 bu/acre, with a mean of 102 bu/acre (Table Yields of the same hybrids grov at 22,000 plants/acre over the thr year period ranged from 89 to 1 bu/acre and averaged 102 bu/ac (Table 5).

Area 2.

Amounts and distribution of rainfall in 1982 were not as good in southern Mississippi as in northern Mississippi. The trial at Raymond was not harvested, primarily because of poor yields resulting from drought.

Yields of all hybrids grown at 16,000 plants/acre averaged 54 and 63 bu/acre at Newton and Poplarville, respectively. Yields averaged over the two locations ranged from 45 to 79 bu/acre, with a mean of 58 bu/acre (Table 6). Root and stalk lodging of most entries was relatively unimportant.

Yields of all hybrids grown at 22,000 plants/acre averaged 51 and 54 bu/acre at Newton and Poplarville, respectively. Yields averaged over the two locations (Table 7) ranged from 37 to 73 bu/acre and averaged 52 bu/acre, 6 bu/acre less than for 16,000 plants/acre.

Harvestable yield of plots planted at the rate of 22,000 plants/acre at Poplarville was not affected by the negligible amount of stalk lodging observed. Therefore, the stalk-lodging data reported in Table 7 reflect rough one half of the stalk lodging obser ed at Newton.

Yields of the 26 hybrids that ha been evaluated in Area Two for t last three years (Table 8) averag 60 bu/acre at 16,000 plants/ac and ranged from 52 to 71 bu/acr Yields of the same hybrids wh tested at 22,000 plants/averaged bu/acre and ranged from 45 to bu/acre (Table 9). Inferences fro these data need to be drawn wi caution, because both plant po ulations were not tested at all sit each year.

Table 1. Location, number of entries, and dates of planting harvest of hybrid corn performance trials in Mississippi, 1982.

Area and County	Location	No. of entries	Planting date	Harvest date
Area 1				
Marshall	Holly Springs	50	May 6	Sept. 21
Pontotoc	Pontotoc	50	March 26	Sept. 9
Lee	Verona	50	April 7	Sept. 17
Washington	Stoneville	50	April 13	Sept. 8
Noxubee	Brooksville	50	April 15	----------
Oktibbeha	Mississippi State	50	March 24	Aug. 25
Area 2				
Newton	Newton	49	March 17	Aug. 23
Hinds	Raymond	49	March 18	---------
Pearl River	Poplarville	49	March 3	Aug. 12

Table 2. Summary of performance of 50 hybrids grown at five locations (Holly Springs, Pontotoc, Verona, Stoneville and Mississippi State) at 16,000 plants per acre in the 1982 Mississippi hybrid corn performance trials.

Hybrid no.	Brand	Yield bu/A	Lodging root %	Lodging stalk %	Ear height cm.	Days to mid silk* no.	Moisture %	Stand %
EXP.8003X	Funk's	142.5	0	1	120	84	15.9	100
EXP.8006X	Funk's	139.8	1	3	115	83	15.2	98
3165	Pioneer	138.3	0	1	119	83	15.1	101
XL394	DeKalb	134.7	0	4	130	85	15.7	101
508	McNair	134.0	0	5	133	91	16.9	99
84aa	McCurdy	132.3	0	6	112	79	14.3	95
3147	Pioneer	131.7	1	4	121	84	16.1	100
21	Coker	131.3	0	6	115	81	14.4	99
XL395A	DeKalb	128.9	0	3	126	88	17.3	100
519	Pioneer	128.0	0	1	128	83	14.4	100
77B	Coker	127.3	1	5	129	86	16.2	97
81-7	McCurdy	126.4	0	2	126	82	14.8	100
G-4525A	Funk's	125.7	0	4	106	77	13.4	98
G-4733	Funk's	124.6	0	2	114	81	15.8	99
PX95	Northrup King	124.6	0	2	130	82	15.3	101
EX7979	DeKalb	124.5	0	3	116	82	13.7	99
PX87	Northrup King	124.5	0	7	115	81	14.3	100
RA1502	Ring Around	124.1	0	5	107	78	14.0	97
JX247	Jacques	123.2	0	6	113	81	14.0	99
8150	McCurdy	122.8	1	2	122	80	15.7	99
G-4673A	Funk's	122.5	0	3	117	80	14.0	103
RA1604	Ring Around	121.3	0	5	115	80	14.2	99
X-300	McNair	121.2	0	6	109	80	15.8	101
8220	Jacques	120.8	0	4	104	78	14.4	99
G-4779W	Funk's	120.3	0	3	122	82	14.6	97
8230	McCurdy	120.0	0	2	123	81	16.1	102
T1230	Trojan	119.9	0	4	112	81	14.7	98
USS2020	Agri-Chemicals	119.0	0	6	118	80	14.4	97
3369A	Pioneer	118.6	0	7	109	76	13.8	97
3184	Pioneer	118.6	0	1	106	79	14.4	99
G-4740	Funk's	117.5	0	2	103	84	15.8	95
XL390B	DeKalb	117.5	0	5	120	80	13.7	99
G-4522	Funk's	117.2	0	4	104	75	13.6	97
RX909	Asgrow	115.5	0	3	102	78	13.5	99
3187	Pioneer	115.4	1	1	115	80	14.8	101
JX227	Jacques	113.9	0	4	112	79	13.3	97
XL72bb	DeKalb	113.7	0	6	104	78	13.9	100
22	Coker	113.5	0	7	114	80	14.8	96
XL71	DeKalb	113.5	0	1	107	78	13.9	98
19A	Coker	111.5	0	3	113	77	13.9	97
RX777	Asgrow	109.2	0	5	106	74	13.5	97
19	Coker	108.6	0	2	110	77	13.4	97
PX707	Northrup King	108.6	1	4	115	79	15.0	98
G-4578	Funk's	107.1	0	3	112	74	13.3	97
PX79	Northrup King	106.8	1	2	115	80	13.4	97
T-E6998	Taylor-Evans	106.2	0	6	107	80	14.3	97
JX180	Jacques	105.1	0	6	115	78	13.3	97
56	Coker	104.4	0	7	116	84	16.9	97
USS1010	Agri-Chemicals	96.7	1	5	112	75	13.7	97
USS0526	Agri-Chemicals	76.1	0	5	102	74	13.3	92
Mean		119.4	0	4	115	80	14.6	98

CV = 13.53%

LSD (.05) = 12.0 bu/A

*Data for Mississippi State only

Table 3. Summary of performance of 50 hybrids grown at three locations (Pontotoc, Stoneville, and Mississippi State) at 22,000 plants per acre in the 1982 Mississippi hybrid corn performance trials.

			Lodging		Ear	Days to	Mois-	
Hybrid	Brand	Yield	root	stalk	height	mid silk*	ture	Stand
no.		bu/A	%	%	cm.	no.	%	%
21	Coker	164.1	0	5	112	81	13.1	99
EXP.8003X	Funk's	153.0	0	1	121	86	15.4	97
XL395A	DeKalb	152.8	0	3	126	88	17.0	95
3165	Pioneer	152.3	0	1	118	84	14.2	99
3147	Pioneer	151.3	0	5	125	84	15.8	95
RA1604	Ring Around	150.8	0	6	116	81	13.5	97
EXP.8006X	Funk's	150.6	0	4	121	86	14.4	97
84aa	McCurdy	149.7	0	9	115	80	13.4	97
JX247	Jacques	149.0	0	7	116	82	14.2	97
EX7979	DeKalb	146.9	0	3	121	83	13.7	95
PX87	Northrup King	146.8	0	9	118	81	13.1	91
8150	McCurdy	146.7	0	4	122	81	15.0	97
508	McNair	144.9	0	7	134	91	16.0	96
G-4673A	Funk's	144.4	0	3	115	82	14.0	95
JX227	Jacques	143.2	0	1	112	80	13.5	98
T1230	Trojan	142.7	0	6	110	82	13.3	97
RX909	Asgrow	142.5	0	3	105	80	13.7	97
3187	Pioneer	139.4	0	2	117	80	13.5	95
RA1502	Ring Around	139.3	0	5	107	80	13.6	98
81-7	McCurdy	138.7	0	6	126	83	14.8	98
USS2020	Agri-Chemicals	138.3	0	4	111	81	13.5	95
8220	Jacques	137.8	0	7	106	78	14.4	94
PX95	Northrup King	137.7	0	7	129	83	13.7	97
G-4740	Funk's	136.6	0	4	107	85	15.8	96
T-E6998	Taylor-Evans	136.3	0	7	113	81	14.4	92
8230	McCurdy	136.0	0	2	118	83	15.1	96
3184	Pioneer	135.9	0	2	109	81	14.6	95
G-4525A	Funk's	135.8	0	7	109	79	12.4	95
G-4522	Funk's	134.8	0	3	105	77	12.8	95
X-300	McNair	134.2	0	12	111	82	15.0	97
PX707	Northrup King	133.8	0	5	118	80	13.0	93
JX180	Jacques	132.4	0	3	117	78	13.3	95
XL394	DeKalb	131.9	0	5	133	85	14.7	93
G-4578	Funk's	131.5	0	3	112	76	12.5	99
19A	Coker	131.3	0	2	112	79	13.0	93
19	Coker	131.3	0	2	110	78	13.0	92
G-4779W	Funk's	131.2	0	4	127	84	14.3	96
XL71	DeKalb	131.1	0	7	105	80	13.9	95
G-4733	Funk's	130.7	0	3	106	82	15.2	96
519	Pioneer	130.4	0	2	130	84	13.8	99
3369A	Pioneer	129.0	0	9	111	77	13.6	92
22	Coker	128.7	0	6	112	80	13.8	95
RX777	Asgrow	128.6	0	2	113	75	13.3	99
77B	Coker	127.9	0	11	136	86	15.5	95
USS1010	Agri-Chemicals	127.5	0	4	113	77	12.9	94
XL72bb	DeKalb	124.8	0	4	111	80	13.2	94
XL390B	DeKalb	121.0	0	9	129	83	14.6	96
PX79	Northrup King	117.3	0	3	114	81	13.5	98
56	Coker	116.2	0	10	118	85	15.6	94
USS0526	Agri-Chemicals	94.7	0	6	104	75	12.2	89
Mean		136.9	0	5	116	81	14.0	96

CV = 11.98%

LSD (.05) = 15.2 bu/A

*Data for Mississippi State only

Table 4. Three-year (1980-82) average performance of 22 hybrids grown in Area I at 16,000 plants per acre in the Mississippi hybrid corn performance trials.

Hybrid	Brand	Yield	Lodging root	Lodging stalk	Ear heights	Days to mid silk	Mois-ture	Stand
no.		bu/A	%	%	cm	no.	%	%
3147	Pioneer	107.5	1	11	120	84	14.8	97
8150	McCurdy	103.5	1	4	122	80	14.7	100
8230	McCurdy	103.0	0	4	119	81	15.3	102
84aa	McCurdy	102.9	0	9	106	79	14.1	97
T1230	Trojan	102.1	0	10	114	81	14.5	99
519	Pioneer	100.0	1	9	125	83	14.9	100
G-4740	Funk's	99.8	1	6	103	84	15.1	97
3369A	Pioneer	99.0	0	9	105	76	13.7	96
PX87	Northrup King	97.4	0	11	116	81	14.4	100
XL394	DeKalb	95.2	1	12	128	85	15.2	102
PX95	Northrup King	95.1	3	13	125	82	14.5	98
19A	Coker	94.8	0	4	112	77	13.8	96
508	McNair	94.7	1	13	136	91	16.0	102
X-300	McNair	94.3	0	17	106	80	14.8	99
19	Coker	93.5	0	4	109	77	13.4	97
XL71	DeKalb	93.0	0	5	109	78	13.5	100
22	Coker	91.8	0	11	115	80	14.4	96
USS1010	Agri Chemical	91.5	1	6	110	75	13.8	98
XL390B	DeKalb	91.0	1	17	124	80	14.5	97
PX79	Northrup King	89.7	2	5	113	80	13.5	97
PX707	Northrup King	89.5	2	8	117	79	14.3	98
56	Coker	89.2	0	10	119	84	16.1	99
MEAN		96.3	1	9	116	81	14.5	99

Table 5. Three-year (1980-82) average performance of 22 hybrids grown in Area I at 22,000 plants per acre in the Mississippi hybrid corn performance trials.

Hybrid	Brand	Yield	Lodging root	Lodging stalk	Ear heights	Days to mid silk	Mois-ture	Stand
no.		bu/A	%	%	cm	no.	%	%
8150	McCurdy	113.2	0	7	122	79	14.6	98
3147	Pioneer	112.8	1	8	122	83	15.2	93
84aa	McCurdy	112.1	0	9	113	77	14.4	96
PX87	Northrup King	109.0	0	11	113	79	14.2	95
T1230	Torjan	107.4	0	9	109	80	14.0	97
USS1010	Agri Chemcial	106.4	1	10	110	75	13.4	96
19	Coker	106.3	0	6	108	76	13.5	92
8230	McCurdy	106.1	1	5	118	81	15.5	97
G-4740	Funk's	104.6	1	7	106	82	15.0	95
19A	Coker	103.1	0	7	113	77	13.8	93
508	McNair	102.3	1	13	133	88	16.2	95
XL394	DeKalb	102.0	1	9	128	84	14.9	93
XL71	DeKalb	101.3	0	10	108	77	14.2	95
3369A	Pioneer	100.2	0	12	108	75	13.9	94
519	Pioneer	99.5	2	9	126	81	14.5	96
X-300	McNair	98.4	0	18	109	80	14.7	92
PX95	Northrup King	96.9	2	11	126	81	13.9	96
PX79	Northrup King	96.8	1	6	115	78	13.4	97
22	Coker	95.0	1	13	111	78	14.2	93
PX707	Northrup King	93.3	2	9	117	79	13.9	95
56	Coker	90.1	0	12	120	83	15.6	95
XL390B	DeKalb	89.4	1	14	125	81	14.5	93
MEAN		102.1	1	10	116	80	14.4	95

Table 6. Summary of performance of 49 hybrids grown at two locations (Newton and Poplarville) at 16,000 plants per acre in the 1982 Mississippi hybrid corn performance trials.

			Lodging		Ear	Mois-	
Hybrid	Brand	Yield	root	stalk	height	ture	Stand
no.		bu/A	%	%	cm.	%	%
508	McNair	79.4	0	1	116	21.4	97
3165	Pioneer	77.8	1	1	89.	20.9	103
12052A	Paymaster	77.0	1	0	91	21.1	105
EXP8006X	Funk's	75.0	0	0	87	21.5	92
81-37	McCurdy	74.4	1	2	95	19.5	100
3147	Pioneer	74.1	0	2	95	20.7	99
EXP8003X	Funk's	68.7	0	1	88	21.4	95
XL395A	Dekalb	68.5	0	1	100	21.9	100
3187	Pioneer	68.0	1	2	86	20.4	98
EX7979	Dekalb	66.9	0	1	89	19.6	92
G-4740	Funk's	66.0	1	2	76	21.6	97
XL394	Dekalb	65.9	0	1	103	17.8	96
RA1604	Ring Around	65.7	0	4	92	18.4	95
RA1502	Ring Around	62.8	1	2	89	18.3	92
3030	Pioneer	62.6	1	1	96	20.9	93
8230	McCurdy	62.5	0	1	89	20.0	95
3320	Pioneer	60.9	2	5	81	18.8	93
PX95	Northrup King	60.8	0	1	95	22.3	95
3369A	Pioneer	59.7	0	2	79	18.1	99
8951	Paymaster	58.6	3	3	89	20.6	95
G-4673A	Funk's	58.3	4	4	87	19.6	94
8220	Jacques	57.8	1	14	79	17.5	89
77B	Coker	57.7	0	2	83	23.4	88
G-4522	Funk's	57.5	1	9	83	20.3	92
519	Pioneer	57.0	1	4	99	16.7	92
G-4733	Funk's	55.5	0	5	83	21.5	87
G-4779W	Funk's	55.5	0	3	96	19.9	93
G-4949A	Funk's	54.8	3	1	96	21.1	96
XL390B	Dekalb	54.4	2	2	103	19.1	95
G-4525A	Funk's	53.9	0	9	78	18.4	92
PX707	Northrup King	53.4	3	3	94	19.3	87
G-4578	Funk's	53.0	2	8	84	19.8	85
8150	McCurdy	52.5	0	4	100	20.2	88
19	Coker	52.4	0	2	84	19.6	78
PX79	Northrup King	52.0	0	2	86	17.2	95
56	Coker	51.3	3	1	93	21.0	90
22	Coker	50.9	0	2	92	20.0	92
X-300	McNair	50.7	1	3	83	22.0	94
JX227	Jacques	50.7	0	0	90	18.4	95
497	Paymaster	50.3	0	0	86	21.3	93
21	Coker	50.2	0	18	87	19.4	90
19A	Coker	50.1	3	6	91	18.3	80
USS2020	Agri-Chemical	50.1	0	8	84	19.0	80
JX180	Jacques	49.7	1	8	85	18.3	87
XL71	Dekalb	48.3	0	7	84	17.4	96
T1230	Trojan	47.7	2	15	84	20.8	90
PX87	Northrup King	46.7	1	14	94	19.7	84
JX247	Jacques	45.2	0	7	85	18.9	93
USS1009	Agri-Chemical	45.0	0	12	73	18.0	83
Mean		58.5	1	4	89	19.8	93

CV = 21.85%

LSD(.05) = 14.5 bu/A

Table 7. Summary of performance of 49 hybrids grown at two locations (Newton and Poplarville) at 22,000 plants per acre in the 1982 Mississippi hybrid corn performance trials.

Hybrid	Brand	Yield	Lodging		Ear	Mois-	Stand
			root	stalk	height	ture	
no.		bu/A	%	%	cm.	%	%
EXP8003X	Funk's	72.9	1	3	88	21.5	99
G-4740	Funk's	71.7	3	3	89	22.0	89
508	McNair	67.9	0	6	109	23.2	91
EXP8006X	Funk's	66.2	0	3	93	20.7	95
77B	Coker	63.9	4	4	117	19.7	92
EX7979	Dekalb	62.3	0	3	102	19.2	96
12052A	Paymaster	62.1	4	2	92	22.2	98
3187	Pioneer	61.9	1	4	93	17.1	94
3165	Pioneer	61.3	0	3	93	21.1	98
8230	McCurdy	61.1	2	3	93	20.5	95
3030	Pioneer	60.3	0	4	96	21.4	91
X-300	McNair	59.4	4	7	88	19.6	93
G-4578	Funk's	59.4	1	9	93	20.8	90
19	Coker	58.1	0	8	87	19.7	90
519	Pioneer	57.8	1	4	95	17.2	93
G-4733	Funk's	56.9	0	6	93	19.6	95
G-4673A	Funk's	56.4	0	8	90	19.1	91
XL395A	Dekalb	55.0	2	3	103	21.9	94
497	Paymaster	54.8	0	6	91	19.1	95
19A	Coker	54.5	0	7	97	18.2	88
3369A	Pioneer	54.1	3	5	85	19.6	88
8951	Paymaster	52.8	0	7	86	18.6	94
3320	Pioneer	52.2	0	7	94	19.4	94
XL71	Dekalb	52.1	0	7	84	21.3	89
8150	McCurdy	52.1	0	5	95	20.8	94
3147	Pioneer	51.5	0	7	100	20.4	99
81-37	McCurdy	51.3	1	10	99	20.1	93
RA1502	Ring Around	51.0	0	9	90	22.5	87
56	Coker	50.4	2	6	97	19.4	85
JX180	Jacques	50.3	0	16	92	18.0	87
USS2020	Agri-Chemical	50.2	0	8	91	18.6	85
XL394	Dekalb	50.0	3	4	95	20.6	93
G-4525A	Funk's	49.5	0	6	93	18.3	88
21	Coker	47.7	0	11	83	18.7	80
PX79	Northrup King	47.3	0	5	94	17.1	96
G-4522	Funk's	46.8	0	8	80	18.1	83
PX95	Northrup King	44.8	0	5	102	21.9	95
JX247	Jacques	44.8	0	14	87	20.1	87
PX707	Northrup King	44.1	1	9	96	21.1	97
G-4949A	Funk's	43.8	1	5	104	21.5	98
XL390B	Dekalb	43.0	1	9	105	21.0	87
JX227	Jacques	42.9	1	4	90	19.7	93
T1230	Trojan	41.5	0	14	89	20.5	87
RA1604	Ring Around	41.3	0	8	91	19.6	94
USS109	Agri-Chemicals	41.2	0	22	73	20.2	90
22	Coker	40.4	1	11	88	19.1	86
G-4779W	Funk's	40.3	0	5	99	22.0	98
8220	Jacques	37.4	1	36	84	21.7	80
PX87	Northrup King	37.2	0	22	87	19.7	90
Mean		52.6	1	8	93	20.1	92

CV = 25.11%

LSD(.05) = 14.9bu/A

Table 8. Three-year (1980-82) average performance of 26 hybrids grown in Area II at 16,000 plants per acre in the Mississippi hybrid corn performance trials.

Hybrid	Brand	Yield	Lodging root	Lodging stalk	Ear height	Mois- ture	Stand
no.		bu/A	%	%	cm	%	%
I2052A	Paymaster	70.6	1	2	93	20.4	96
3147	Pioneer	68.4	1	5	90	17.9	94
XL395A	DeKalb	67.5	1	6	99	20.1	94
3030	Pioneer	64.9	1	5	99	19.9	97
G-4740	Funk's	64.6	0	4	79	19.0	95
8951	Paymaster	64.5	1	5	93	18.3	96
519	Pioneer	62.5	1	4	98	16.9	93
508	McNair	62.2	0	6	112	20.5	97
3320	Pioneer	62.0	1	3	81	17.2	92
8150	McCardy	61.4	1	4	96	17.2	93
XL394	DeKalb	59.9	1	5	98	17.9	95
T1230	Trojan	59.5	1	15	90	18.5	93
USS2020	Agri Chemicals	59.4	0	8	88	18.2	89
PX79	Northrup King	59.2	0	3	90	16.0	96
19	Coker	58.4	0	4	83	16.7	86
PX95	Northrup King	57.3	0	3	98	19.3	92
19A	Coker	57.2	1	5	89	16.7	93
3369A	Pioneer	56.3	1	7	78	16.9	93
G-4949A	Funk's	56.0	3	7	99	20.0	96
PX707	Northrup King	55.5	1	5	94	17.6	91
XL71	DeKalb	55.5	0	9	82	16.6	98
56	Coker	54.6	2	8	96	18.8	89
X-300	McNair	54.5	0	5	83	19.1	94
XL390B	DeKalb	54.4	2	12	103	18.2	89
PX87	Northrup King	53.7	1	12	90	17.3	90
22	Coker	52.1	0	7	87	18.2	94
MEAN		60.0	1	6	92	18.2	93

Table 9. Three-year (1980-82) average performance of 26 hybrids grown in Area II at 22,000 plants per acre in the Mississippi hybrid corn performance trials.

Hybrid	Brand	Yield	Lodging root	Lodging stalk	Ear height	Moisture	Stand
no.		bu/A	%	%	cm	%	%
G-4740	Funk's	67.4	2	6	83	19.4	87
XL395A	DeKalb	63.2	1	3	99	20.3	90
3147	Pioneer	60.9	0	9	94	18.0	91
508	McNair	59.3	0	12	108	21.9	85
19	Coker	59.2	2	6	86	17.1	87
12052A	Paymaster	59.1	3	4	93	22.0	89
3320	Pioneer	58.9	0	6	87	17.6	88
USS2020	Agri Chemicals	58.8	0	6	92	17.5	85
3030	Pioneer	58.3	1	6	101	20.2	90
519	Pioneer	58.1	1	6	97	16.5	92
19A	Coker	58.0	0	9	93	16.6	88
8951	Paymaster	57.8	0	7	89	17.4	90
8150	McCurdy	57.5	0	6	97	18.0	92
XL394	DeKalb	57.3	1	4	100	18.9	86
X-300	McNair	56.4	2	9	86	18.1	81
XL71	DeKalb	54.6	0	12	85	17.9	83
T1230	Trojan	53.3	0	11	86	18.3	83
PX79	Northrup King	53.0	0	3	90	15.9	91
3369A	Pioneer	51.8	1	9	83	16.8	86
PX87	Northrup King	51.3	1	18	88	17.6	91
G-4949A	Funk's	51.1	1	7	104	19.7	91
22	Coker	51.0	0	13	87	17.9	82
PX95	Northrup King	50.9	1	6	100	19.2	89
PX707	Northrup King	50.3	0	9	95	18.3	88
56	Coker	47.1	1	10	95	19.5	80
XL390B	DeKalb	44.6	1	16	104	19.1	85
MEAN		55.7	1	8	93	18.4	87

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Patio Peach Trees

From Cuttings

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PATIO PEACH TREES---From Cuttings

SUMMARY

Our experiments show how leafy stem cuttings from peach trees in an orchard can be rooted and grown into fruiting trees by procedures as follow:

1. Prepare a mist bed with controls for duration and frequency of misting. A pasteurized, suitable sand-perlite mixture should be 5 to 6 inches deep.
2. Actively growing cuttings (shoots 6 to 8 inches long) should be collected from the orchard. Six-inch long terminal and subterminal cuttings are suitable. Mid-summer was found to be the proper time. Cuttings must be kept moist at all times or they will wilt and/or die. If they cannot be prepared and inserted in the bed the day they are collected, store them at 40°F and high relative humidity.
3. Cuttings should be dip treated in a fungicide-water mixture, such as Captan®, just before the hormone treatment and insertion in the bed 1 or 2 inches apart in rows 6 inches apart.
4. Hormone treatment for base of cuttings can be IBA in talc at 0.3%. Other effective treatments are IBA or IAA in an an ethyl-alcohol-water mixture at 1000 to 2000 ppm, but these were more difficult to apply.
5. Misting is recommended from one hour after sunrise to one hour before sunset. Recommended frequency is from once per minute for new cuttings to once per 5 minutes for cuttings that have been well rooted. Recommended duration of misting is 2.5 seconds.
6. Rooted cuttings should be potted into a loose, well-drained potting mixture in 1-gal containers. A mixture that has been effective in these experiments is four parts shredded pine bark (less than 1-inch diameter), three parts masonry sand and one part pasteurized silty loam soil. Necessary mineral additions are dolomitic limestone to adjust the pH to 6 to 6.5, slow release NPK fertilizers and small quantities of other minerals (boron, copper, iron, manganese, molybydenum and zinc).
7. Plants may be grown outdoors in the first summer. They should be transferred from 1- to 3- and then to 5-gal containers with a good potting mixture that gives adequate drainage.
8. Water can be applied daily by trickle irrigation, overhead sprinkler or hand watering. Frequency is dictated by need to prevent serious drought stress. Watering should allow for 10% drain to leach the bottom of containers to eliminate soluble salt build-up.
9. During winter periods, the plants must be protected from damage from low temperatures by banking sawdust or pine bark around the containers.
10. Adequate insect and disease controls must be applied to prevent damage to fruits and trees.
11. Yields, life expectancy and plant vigor will relate to management by the owner. Cultivar selection will determine season of ripening as well as dictate potential yields and fruit qualities. However, this study shows that use of McNeely, Redhaven, Sunqueen and Loring will result in fresh fruit being intermittently available over five weeks

Peach trees in commercial orchards in the United States, and worldwide, are propagated with seedling rootstocks and scion tops of chosen cultivars. More than 100 cultivars are being tested for their fresh market fruit potential in the research orchards at the Pontotoc Ridge-Flatwoods Branch of the Mississippi Agricultural and Forestry Experiment Station (MAFES).

Peach trees purchased from nurserymen in the southeastern United States often have either Lovell or Halford seedling rootstocks. These stocks have been used in this climatic region because they have been graft-compatible and produce vigorous trees of most peach cultivars. Sometimes these rootstocks may be susceptible to diseases and/or nematodes, and specialized rootstocks such as Nemaguard may be used.

Recent changes in the economics of peach growing have led growers to attempt to improve yields per acre. This sometimes has led to high density plantings (14). Such plantings may range from 200 to 3000 or more trees per acre. Grafted nursery propagation is expensive, and growers of high density orchards have considered means of producing trees from cuttings (3, 4, 5, 6, 7, 8, 12, 14, 15).

Techniques for rooting leafy stem cuttings from peach trees (including hormone treatments to promote rooting) have been studied since 1955 (3, 5, 6, 7, 8, 11, 12). However, this technique is not used widely in the southeastern United States for the production of peach trees for general orchard use. The use of cuttings for high density orchards is increasing, especially in the "meadow orchard". These trees may be spaced 1 ft apart in rows 8 to 14 ft apart and pruned severely immediately following harvest to maintain a low hedge. The number of research trials with meadow orchards is increasing in the United States.

Trees of standard cultivars in nursery containers for dooryard use by homeowners have been labe "Patio Peach Trees". This proc is described, beginning with search on methods of rooting le peach cuttings from standard or ard trees in the Fresh Market Pea Variety Test (14) at the MAF Pontotoc Ridge-Flatwoods Bran

MATERIALS AND METHODS

Making Leafy Stem Cuttings

Cuttings of healthy new shoots (6 to 18 inches long) were collected in mid- to late summer in the orchard, wrapped in paper toweling, soaked in water, placed in a plastic bag in the shade, transported to Mississippi State University and refrigerated overnight at 40°F.

The propagation bed was well drained because a gravel layer was over-laid with 6 inches of a mixture of masonery sand and perlite, 1:1 (v/v), Figure 1. Before inserting cuttings in the bed, the potting mixture was steam pasteurized at 180°F for 2 hours to control disease organisms.

A misting system as described Hartmann and Kester (9) and He (10) was used for rooting the c tings. Fog-Mist® nozzles man factured by Sprayers and Nozzl Company of St. Petersburg, Florid were spaced so that the mist ov lapped all cuttings in the bed.

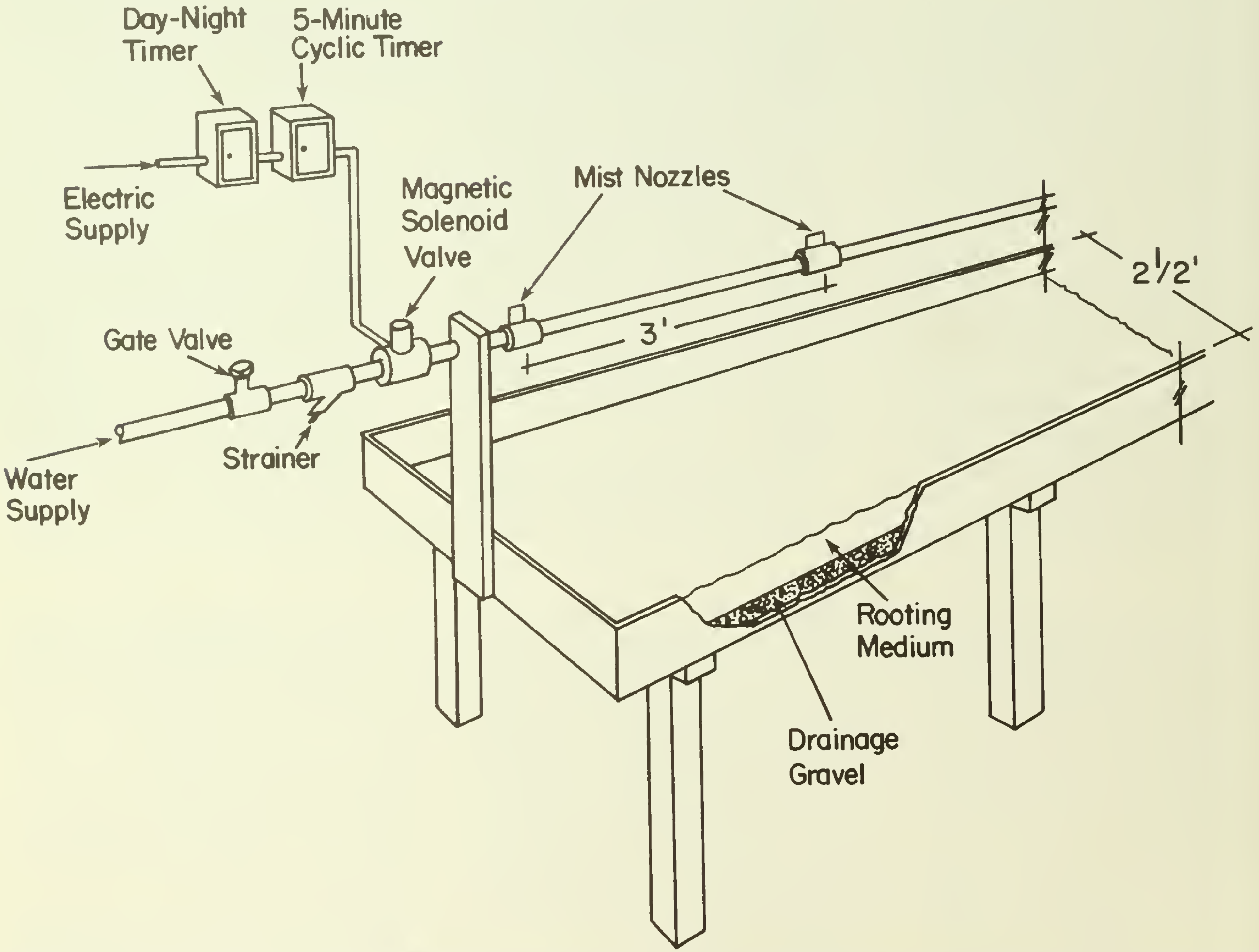

Figure 1. Intermittent mist propagating bed with on-off day-night timer and cyclic timer to regulate interv between misting periods.

Misting time was controlled by a -hour time switch, and the daily ration was from an hour after nrise to an hour before sunset. n intermittent, repeat-cycle timer as used to control frequency of isting. Newly set cuttings were isted once per minute. This freency was gradually extended to ce per 5 minutes, for hardening cuttings a few days before potng. Misting duration was 2.5 conds per cycle.

Cuttings were made 6 inches long, d leaves were removed from 3 ches of the basal portion of the tting to provide a leaf-free zone r insertion in the medium. Two posite vertical cuts (1/2-inch long) ere made through the bark at the se of the cuttings. Cuttings were mersed in a 1:400 (w/w) aptan® (fungicide) water mixture control diseases. They were then ven a hormonal treatment before sertion in the medium.

The base of the treated cutting en was inserted in a punched ole (3/8 inch-diameter) at 2 inches deep. The medium was then firmed against the stem of the cutting and was hand watered to settle the medium around the base. Spacing was 1 x 6 inches between cuttings. After one week in the mist bed, applications of a water soluble 20-20-20 (N-P_2 0_5-K_2 0) solution of fertilizer (1/4 oz/3 gal of water) were made weekly. The rate of application was 1 gal per 30 sq ft of bed space.

After five to nine weeks in the propagation bed, the cuttings were removed and scored as to amount of roots formed, Figure 2. Cuttings with a score of 2 or higher had a 90% or better survival rate when transplanted (one plant per container).

The potting mixture consisted of four parts shredded pine bark (under 1-inch diameter), three parts coarse masonry sand and one part silty loam soil (v/v/v), which was steam pasteurized at 180°F for 2 hours before incorporation into the mixture. This mixture was designed and used by Bostian and Overcash (1) for growing pecan seedlings in containers, with good growth response.

Chemicals added to a mixture of 32 qts of pine bark, 24 qts of sand and 8 qts of soil were 7.4 oz dolomitic limestone, 2.5 oz of 20% superphosphate, 1.3 oz calcium sulfate, 4.9 oz Osmocote® 18-6-12 (N-P_2 O_5-K_2 O of 8-9 mo release rate) and 0.2 oz of Peters Fritted Trace Elements® (7.5% Mn, 18% Fe, 3% Cu, 7% Zn, 3% Bo and 0.2% Mo). The potting mixture with all chemicals added was then mixed in an electric soil blender to obtain uniformity. This mixture has been quite effective for production of woody plants in containers. It has good drainage and reasonable nutrient holding capacity---the slow-release (N-P-K) fertilizer provides measured amounts of these elements over several months (13). The pH of the medium mixture after one growing season usually has ranged from 6.0 to 7.0.

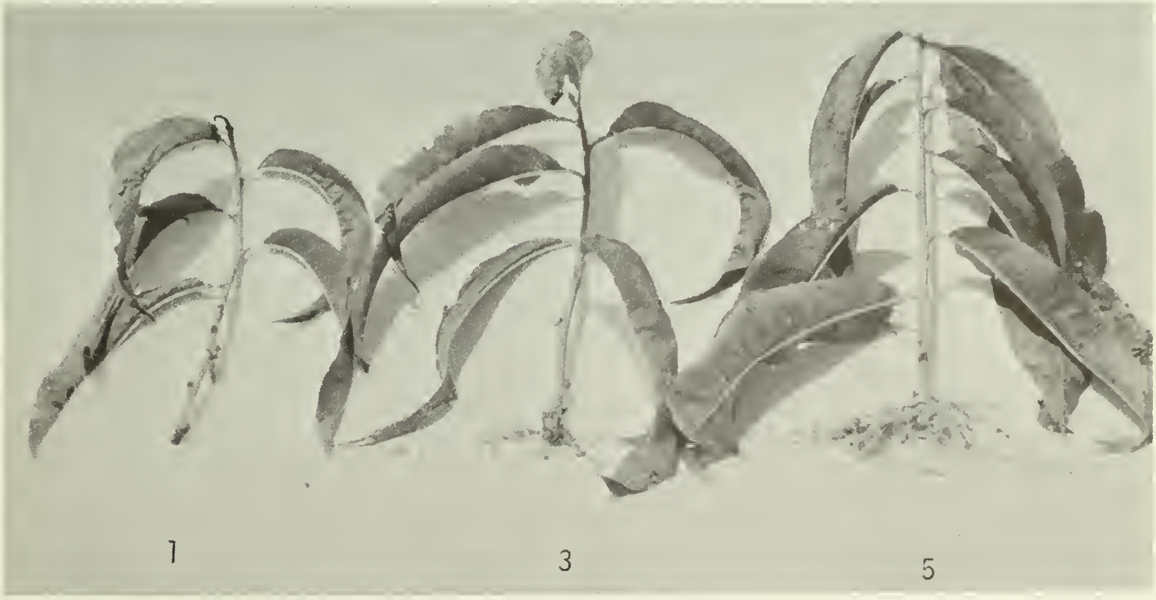

Figure 2. Degrees of rooting for peach cuttings on July 12, 1979 after five weeks in the mist propagation bed: 1 = no roots, 3 = moderate amount of roots with excellent survival after potting, and 5 = excellent roots and survival.

The Influence of Hormones on Rooting

A study of two growth-regulating hormones, indolebutric acid (IBA) and indoleacetic acid (IAA) was started August 1, 1978 (8). The study was conducted with three cultivars ---Harvester, Norman and Washington. Ten cuttings of each cultivar were used as a control and ten were treated with Hormodin No. 2® (0.3% IBA in talc), Hormodin No. 3® (0.8% IBA in talc), a quick dip of IBA or a quick dip of IAA. Both quick-dip hormoness were at concentrations of 500 or 1000, or 2000 parts per million (ppm). The trial was replicated four times.

The base of cuttings treated with the commercial talc hormone was dipped 0.5 inches deep, and surp talc was removed by tapping base. The pure IBA and IAA w dissolved in small amounts ethanol and were diluted to specified concentrations with wa and cuttings were inserted into mixture 1 inch deep for 1 min.

Producing Container Nursery Trees from Cuttings

Cuttings from Harvester, Norman and Washington were made in late summer of 1978 and were potted into 1 pt containers after rooting. They were kept in a greenhouse until December 16 and were then placed in a refrigerator at 40°F until March 6, 1979,to break the rest period. The plants were returned to the greenhouse and transplanted in the Bostian-Overcash potting mixture in one gallon containers. The plants were kept in the greenhouse at 50°F or higher until May 11.

Plants were then transplanted into 3 gal nursery containers with the Bostian-Overcash mixture, plus the normal rate of Osmocote (X rate) or the Bostian-Overcash mixture plus twice the normal rate of Osmocote (2 X rate). Harvester, Norman and Washington were used in this test.

In another test, Norman ar Harvester were used to determi the influence of supplemental wat soluble 20-20-20 (N-P_2 O_5 -K_2 (One pint of a mixture of 0.17 oz 20-20-20/3-gal container w applied each week from May 21 July 23. The growth criterion recor ed was the increase in trunk heig between the two dates. Growth aft bud break was limited to the term nals by removing lateral shoo each week.

Rooting Effect as a Function of Position on the Shoot from which Cuttings were Made

New succulent shoots available for making cuttings from peach trees often range in length from 6 to 18 inches or more. An experiment was conducted to determine the rootability of cuttings from 18-inch long shoots. Cuttings were made 6 inches long from the terminal, middle and basal portions of these shoots. Cultivars used were McNeely, Sunqueen and Washington, and the three hormonal treatments were IBA in talc at 0.1, 0.3 and 0.8%. Ten cuttings of each cultivar were used for each hormone treatment of each shoot positi and the trial was replicated fo times. The experiment was initiat on July 29, 1980, the cuttings we removed from the mist bed fi weeks later, and numbers of root cuttings were recorded.

Production of Patio Peach Trees from Rooted Cuttings in Containers

Patio Peach Trees have been defined as those grown in containers with the intention of producing fruit on the home patio or in the dooryard. This involves vegetative propagation by leafy stem cuttings and tree growth capable of producing many fruit buds.

Leafy stem cuttings were made and rooted under intermittent mist in late summer 1979 and were transplanted after rooting into standard 1-gal containers. The Bostian-Overcash potting mixture was used and the plants were grown in the greenhouse until December. At that time, they were given a 30-day chilling period at 45°F to break their rest. They were then returned to a greenhouse at 50°F minimum temperature, at which time they began to grow. In March 1980, they were transferred to 3-gal containers with the same potting mixture. In July 1980, they were transplanted into 5 gal containers with the same potting mixture.

When the trees began to grow in the spring, they were trained weekly to one stem. When they were 19 inches above the containers, the growing tip was removed. Three side shoots were developed into primary scaffold limbs. When these shoots were 6 to 10 inches long, they were tipped to promote furth branching to develop a miniatu tree with the shape typical of open-center orchard tree. The tr in each container was tied to a 3 inch steel rod to permit develo ment of the desired shape. Week training kept the trees in the desir shape, with a minimum amount growth removed.

In May and June 1980, mar plants were growing at the rate 1/2 inch per shoot per day. Th were healthy and dark green color until July when unusual high temperatures occurred ar growth rate was reduced. The tre were growing in black plastic co tainers on a concrete floor in fu un and were hand watered daily.

On June 1, five supplementary ertilizer programs were initiated, sing four replicates of a random esign of one-tree plots of each cultivar x fertilizer combination. Rates nd dates of application are shown Table 1. Cultivars were Harbrite, IcNeely, Princess Anne and Sunueen. The basic rate (F1) was 0.28 z (.8 gm) of actual N per container er week. The fertilizers were (1) ta-Green* Super Nursery® 20-5-10 N-P_2O_5-K_2O) including supple- ents of 0.02% boron, 0.05% copper, .10% iron, 0.05% manganese, .0005% molybdenum and 0.05% inc; (2) 20-20-20 (N-P_2O_5-K_2O) ater soluble fertilizer at two rates nd (3) Calcium nitrate** (15.5% N) t two rates.

Total length of growth for all caffolds, plus secondary and tertiry branches, was recorded at the nd of the growing season. Canopy olume was calculated, using width x height to top of tree from the lowest limb in the crotch.

Table 1. Fertilizer treatments for container-grown "Patio Peach" nursery trees from cuttings of Harbrite, McNeely, Princess Anne and Sunqueen.

Treatment		Weekly rate of N/container			
No.	Fertilizer	June 1-15	June 22 - July 6	July 13-27	August 3-17
		gm			
F1	Sta-green (20-5-10)*	0.8	0.8	0.8	0.8
F2	Low 20-20-20**	0.8	0.8	0.8	0.8
F3	High 20-20-20	0.8	1.6	2.4	3.2
F4	Low $Ca(NO_3)_2$	0.8	0.8	0.8	0.8
F5	High $Ca(NO_3)_2$	0.8	1.6	2.4	3.2

*(N-P_2O_5-K_2O) plus minor elements: B, Cu, Fe, Mn, Mo and Zn.

**Water soluble (N-P_2O_5-K_2O).

Cultivar Studies

One-tree plots of Candor, Compact Redhaven, Harbrite, Harken, Harvester, Jefferson, Loring, McNeely, Norman, Princess Anne, Redhaven, Rosy Dawn and Sunqueen in 5-gal containers were studied. The supplemental fertilizer program was the same as F3 in Table 1. All growing methods were the same as in the fertilizer test. The experiment was a random design with four replications.

ruit Production on Patio Peach rees

In the spring of 1981, seven ultivars--- Harbrite, Loring, IcNeely, Princess Anne, Redhaven, unqueen and Washington---were elected for fruiting. Four one-tree eplicates were selected for uniormity and were randomized on n outdoor concrete floor with spacng between trees of 4 x 5 feet. The rees were protected from insects nd diseases by standard insecticide and fungicide applications, and were watered daily as needed.

The residual mineral content of the mixture was low because the trees had been potted in the Bostian-Overcash potting mixture for 2 1/2 years---first in a 1-gal container, then a 3-gal container and finally a 5-gal container. The need for substantial supplemental fertilizer elements was met by applying (1) Osmocote® 16-8-12 (8 to 9 mo release rate) at .33 oz/container on the surface of the potting mixture in mid March and at monthly intervals thereafter until mid September and (2) a fertilizer solution containing water-soluble 20-20-20 (N-P_2O_5-K_2O) at 0.5 oz/gal of water at 1 pt/container weekly. The pH was maintained above 6.0. Results recorded were dates of ripening, yields of fruit/tree in lbs and average fruit diameter.

RESULTS AND DISCUSSION

he Influence of Hormones on ooting

The dramatic increase in rooting f leafy stem cuttings following the se of hormones is shown in Table and Figure 3. Rooting percentage average of three cultivars) was only 5% for the check (no hormones), and the ones that rooted had very weak roots. Differences in percentages of rooted cuttings among cultivars were not significant, suggesting that reported differences in rooting between cultivars (6) may not have been genetic but may have been differences in stage of growth, and/or vigor of the shoot and/or trees from which cuttings were collected.

The best treatments were 0.3 and 0.8% IBA in talc and IAA quick-dip

**Supplied by Sta-Green Plant Food Company, Sylacauga, Alabama 35150.*

***Supplied by Viking Ship Branch Agricultural and Industrial Chemicals of San Francisco, California.*

liquid at 1000 and 2000 ppm, which averaged 75% rooting. These rooting percentages are entirely acceptable for efficient propagation of peach trees from cuttings.

Hormones applied as quick dip (liquid) were more effective at 2000 ppm than at 500 ppm for both hormones, and 1000 ppm IAA was better than 500 ppm IAA in promoting rooting.

There was a direct positive correlation between larger percentages of cuttings rooted from the hormone treatments and the extensiveness of root development (Table 2). The largest root systems (per cutting) were from 0.3 and 0.8% IBA in talc and IAA quick dip at 1000 and 2000 ppm.

IBA in talc is readily available in many garden stores; therefore, it can be a convenient source of a root-promoting hormone. IAA as a quick dip requires ethyl alcohol as a solvent, along with accuracy in dilution. Thus, it is more complicated for a propagator to use.

Producing Container Nursery Trees from Cuttings

Peach trees produced in containers have many fibrous roots (Figure 4), which is in contrast with the large and branched root system of the typical nursery tree that has been grafted on a seedling rootstock. These fibrous roots often literally fill the container of potting mixture of pine bark, sand and soil.

The rooted cuttings of Norman and Washington made outstanding growth in 3-gal containers from May 21 to July 23, 1979 and until the end of the growing season (Figure 5). Some trees trained to a single trunk were more than 6 ft tall.

The greatest increase in trunk height from May 21 to July 23 (10 weeks) was by Norman trees fertilized with the 2X Osmocote rate plus weekly applications of a water soluble 20-20-20 (N-P_2O_5-K_2O) fertilizer (Table 3)---this was at the rate of 0.4-inch daily increase in

Table 2. The influence of hormone treatments on rooting of leafy cuttings
three peach cultivars under intermittent mist from August 24 to October 11, 19

Treatment	Rooting Percentage				Amount
	Cultivar				roots/
	Harvester	Norman	Washington	Average	cutting
	-----------------------	----------%	----------------------		--score
Check	0	10	5	5 h**	1.15 b*
0.3% IBA in talc**	70	65	95	77 ab	3.35 a
0.8% IBA in talc**	60	75	75	70 abcd	3.12 ab
IAA 500 PPM	30	75	40	48 e	2.48 cd
IAA 1,000 PPM	90	65	90	82 a	3.27 ab
IAA 2,000 PPM	70	85	70	75 abc	2.97 ab
IBA 500 PPM	30	10	20	20 fg	1.38 g
IBA 1,000 PPM	20	25	30	25 fg	1.43 fg
IBA 2,000 PPM	45	40	30	38 ef	2.10 ef
Average***	46 a	50 a	51 a		

*1.0 - no roots; 5 - dense roots 1 to 2 inches long.

**0.3 IBA-talc - Hormodin 2®, .08 IBA-talc - Hormodin 3®.

***Means followed by the same letter do not differ significantly, using Duncan'
Multiple Range Test at the 0.05 level.

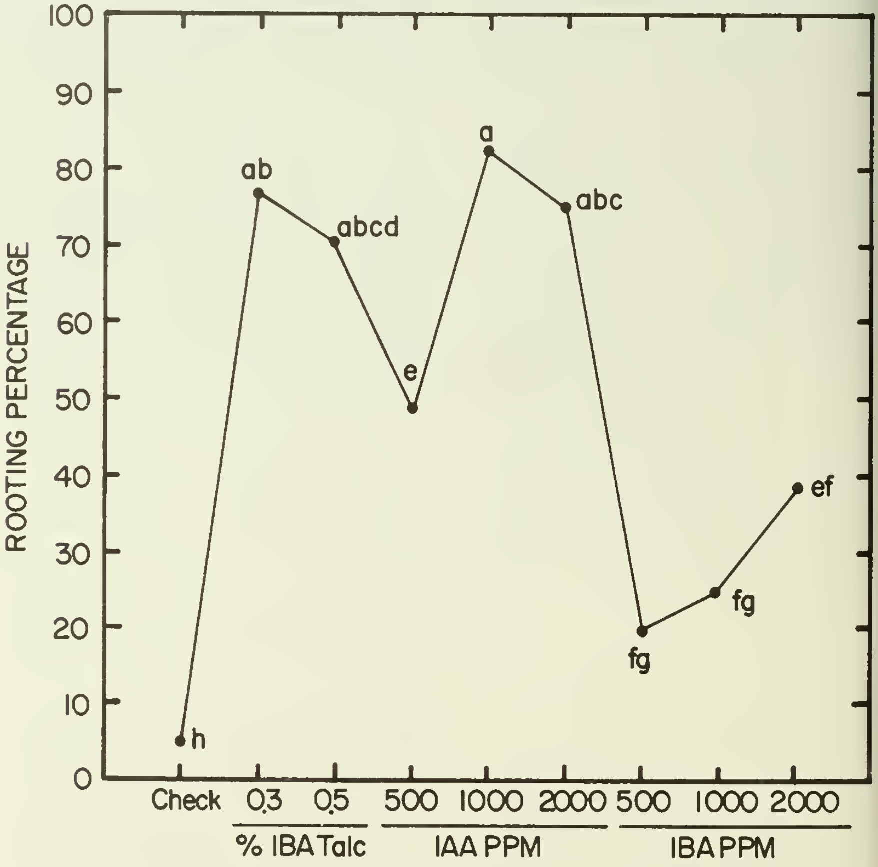

Figure 3. Average rooting percentages for leafy cuttings of three peach cultivars (Harvester, Norman and Washington) in response to dip treatment of base of cuttings with root-promoting hormones before insertion in medium of mist bed. Cuttings were made on August 21 and removed from the bed on October 11, 1978. (Treatment means not followed by a common letter differ ($P < .05$) as determined by Duncan.)

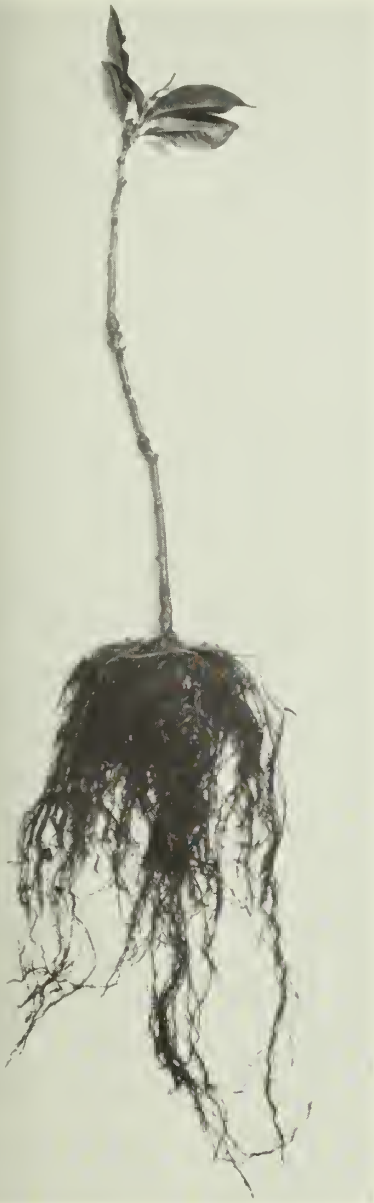

Figure 4. Fibrous root system of a peach tree rooted from a cutting and grown for three months in a 1-gal can.

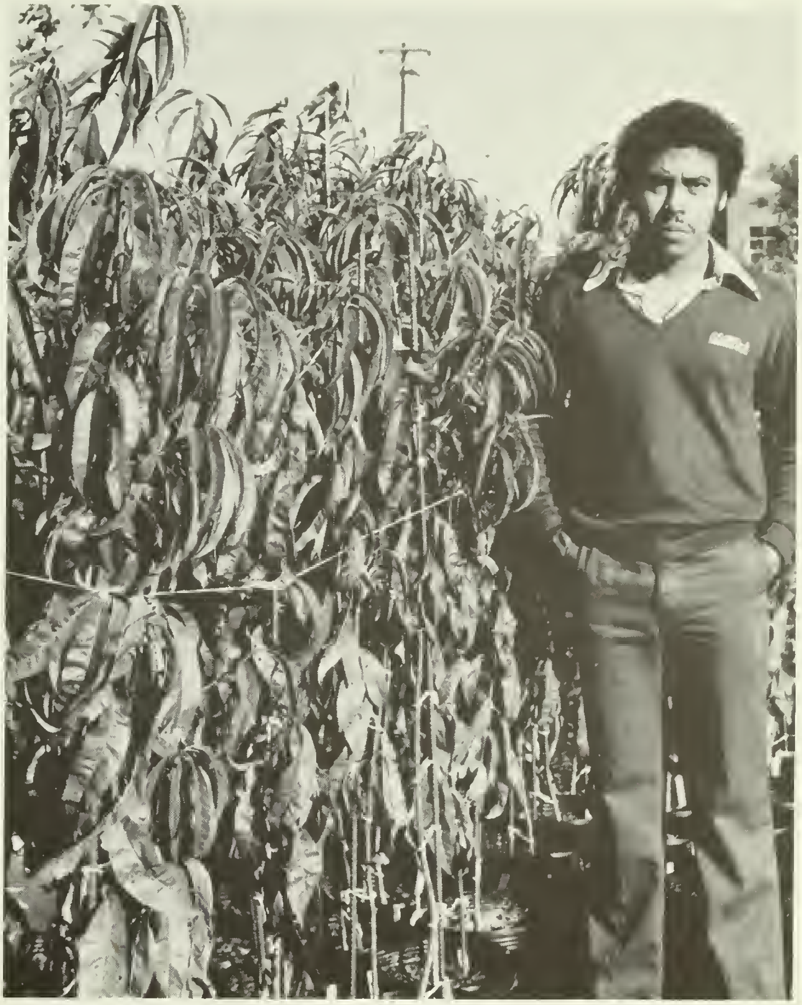

Figure 5. Medardo Galindo with tall potted patio peach trees from cuttings after one summer's growth in 3-gal containers.

Table 3. The influence of fertilizer programs on the increase in trunk height by potted trees of two peach cultivars (grown from cuttings made in 1978) during the period May 21 to July 23, 1979.

		Increase in trunk height by Biweekly Intervals				
Cultivar	Treatment	2	4	6	8	10*
		inches				
Norman	X	3.3	9.0	17.7	15.1	25.7 d
Norman	X + NPK	3.5	8.4	17.5	25.9	28.7 cd
Norman	2X	5.7	11.5	21.1	28.1	33.6 b
Norman	2X + NPK	7.1	15.5	26.7	34.0	40.1 a
Washington	X	2.6	6.1	12.2	16.4	21.2 e
Washington	X + NPK	2.9	8.7	17.0	22.8	27.3 d
Washington	2X	4.7	9.3	16.7	24.4	27.9 cd
Washington	2X + NPK	5.2	10.1	18.5	27.0	31.6 bc

*Means not followed by the same letter differ significantly using Duncan's Multiple Range Test at the 0.05 level.

trunk height during the 10 weeks. The least growth was by Washington at the X Osmocote rate.

The best growth by trees of both cultivars was by those fertilized with the 2X Osmocote rate plus weekly supplemental applications of water soluble 20-20-20 (N-P_2O_5-K_2O). The next best treatment was X Osmocote with the weekly supplement, and the poorest growth was by trees receiving the X rate of Osmocote without the supplement.

These growth rates indicate that the X rate and 2X rate of Osmocote were not adequate for maximum growth from March to late July. This was true even though the Osmocote was released over a eight- to nine-month period. Appa ently, the rate of availability c NPK from Osmocote is accelerate during hot summer months and di not provide adequate season-lon fertilization at the rate applied.

Table 4. The effect of position and hormone treatment on rooting percentage of three peach cultivars (McNeely, Sunqueen, Washington) in 1980.

	Cuttings with Roots			
	Position			
% IBA-talc	Tip	Middle	Base	Average*
	%			
0.1	10.3	5.3	10.7	9.9 a
0.5	43.3	43.3	39.7	42.1 b
0.8	39.0	55.3	37.3	44.4 b
Average**	31.4	41.5	29.2	

*Means not sharing a common letter differ significantly at Duncan's .05 level.

**Means not sharing a common letter differ significantly at Duncan's .05 level.

Table 5. The influence of five fertilizer treatments on trunk and circumference of "Patio Peach" trees from cuttings and total limb growth of four peach cultivars in nursery containers on October 18, 1980.

Cultivar	Treatment[y]	Trunk circum.	Limb growth
		inches	
Harbrite	F1	4.3 a[z]	127 a[z]
	F2	4.6 a	110 a
	F3	3.6 b	67 c
	F4	4.8 a	159 b
	F5	3.8 b	113 a
McNeely	F1	4.4 a	117 a
	F2	4.4 a	132 a
	F3	3.5 b	97 b
	F4	4.6 a	113 a
	F5	3.9 a	112 a
Princess Anne	F1	4.6 a	95 a
	F2	4.8 a	113 b
	F3	3.8 b	70 c
	F4	4.7 a	104 a
	F5	4.2 a	93 b
Sunqueen	F1	4.8 a	109 a
	F2	4.8 a	128 b
	F3	4.3 b	128 b
	F4	4.6 a	106 a
	F5	4.2 b	128 b

[y] F1 - Sta-green, F2 - low 20-20-20, (N-P_2O_5-K_2O),

F3 - high 20-20-20, F4 - low CA $(NO_3)_2$ and

F5 - high CA $(NO_3)_2$.

[z] Means of each cultivar not sharing a common letter differ significantly by Duncan's Multiple Range Test at the 0.5 level.

Rooting Effect as a Function of Position on the Shoot from which Cuttings were Made

Cuttings of McNeely, Sunqueen and Norman given basal treatments of IBA in talc at three concentrations showed large differences in rooting percentages. The 0.1% concentration was too weak and was not very effective in promoting roots (Table 4). However, cuttings treated with either 0.3 or 0.8% IBA were equally effective in promoting roots. There were no differences in the amount of rooting by cuttings made from the tip, middle or basal portion of the 18-inch portion of vigorous peach shoots in mid-summer.

The 0.3% IBA in talc as a basal treatment of leafy stem cuttings propagated under intermittent mist is less expensive and just as effective as the 0.8% IBA formulation. If a propagator is making peach cuttings from an orchard tree, he may effectively make both terminal and subterminal cuttings, knowing that, while they are still actively growing, they have good rooting capability.

Production of Patio Peach Trees from Rooted Cuttings in Containers

Growth of rooted cuttings of Harbrite, McNeely, Princess Anne and Sunqueen own-rooted peach trees planted in 5-gal containers for the study of supplemental fertilizer treatment (Table 1) is reported in Table 5. There were no apparent differences in cultivar response to fertilizer supplements.

All trees in the treatment with high level supplement of 20-20-20

(-P_2O_5-K_2O), regardless of cul- t ar, were in the lowest or a low g owth category. Under ordinary c cumstances, when large, actively g owing plants are supplied addi- t nal fertilizer, there is an increase i growth. An unusal "heat wave" i July of 1980 (Figure 6) produced c trimental effects on plants--- i cluding those in containers as ell as those growing in soil. Heat cumulation in the container-grow- ig area (on or just above the floor) as excessive.

The duration and intensity of the gh temperatures in July and ugust, 1980, caused acute reduc- on in growth rate of all trees in ntainers. The poor growth by trees ith the high 20-20-20 (N-P_2O_5- $_2O$) fertilizer supplement may ave resulted from toxicity of the rtilizer concentrations and am- ient heat above optimum growing onditions. The somewhat un- hrifty condition of one tree is shown Figure 7.

Wong and others (15) have dis- ussed the influence of high soil emperatures on woody plants. In ur study, roots against the con- ainers were killed when the black lastic was exposed to the sun. The educed rate of vegetative growth, ecause of excessive ambient temperatures, caused the trees to initiate and "set" a large crop of fruit buds during this period of time.

In a test of 13 cultivars with four replicates of each, there were tremendous differences in tree growth, either because of varietal characteristics or physiological conditions of the cuttings at the time they were rooted (Table 6). Sunqueen trees grew the most (total inches of shoot growth beyond the trunk), and Candor, along with Compact Redhaven, Harbrite, Harken, Harvester and Jefferson, grew the least.

This test indicated that there are true genetic differences in vegetative growth between cultivars. Compact Redhaven is classed as a somewhat dwarf tree type, even when it is grafted on a vigorous rootstock.

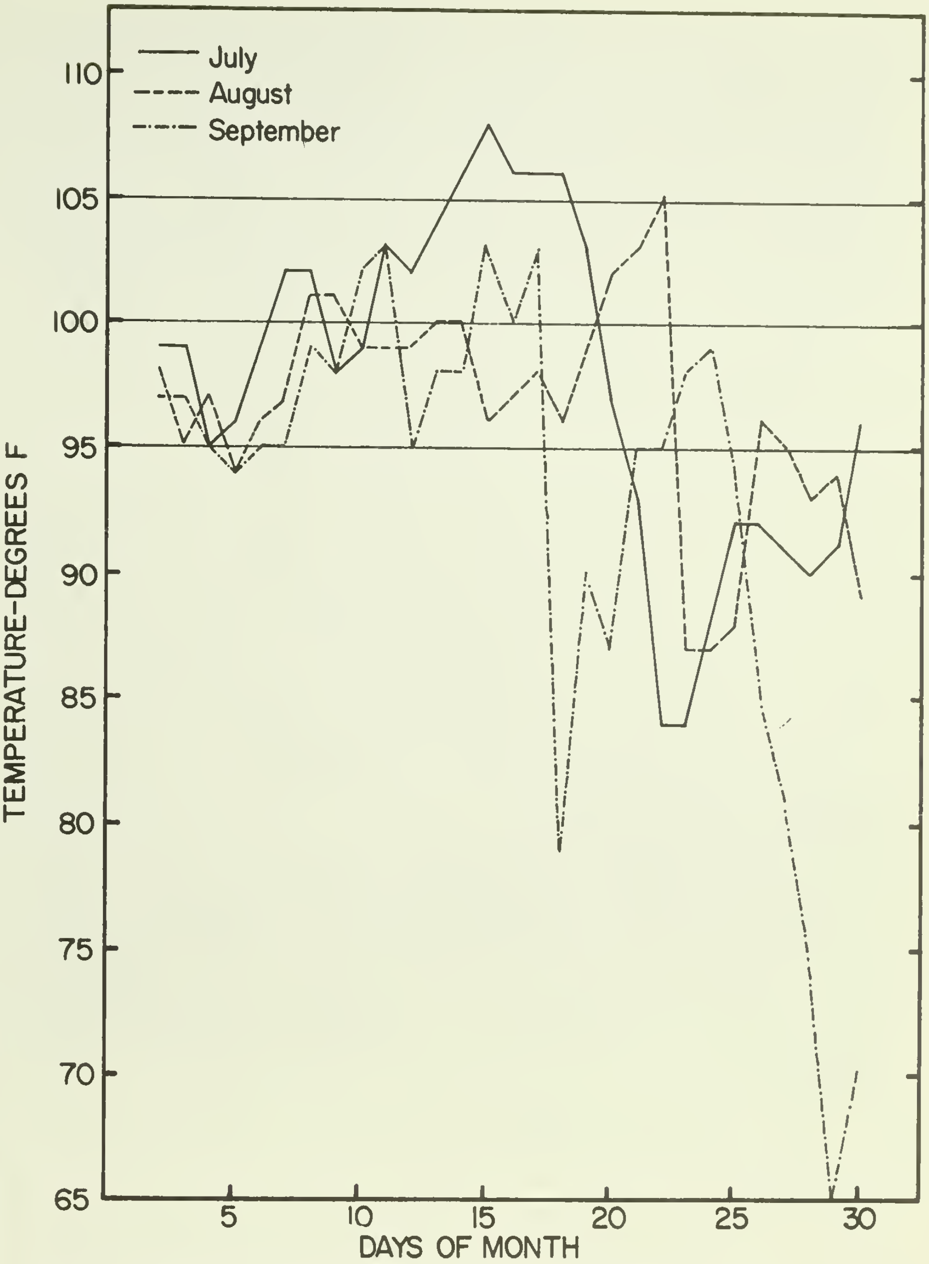

Figure 6. Daily maximum air temperature at Mississippi State University during the summer of 1980.

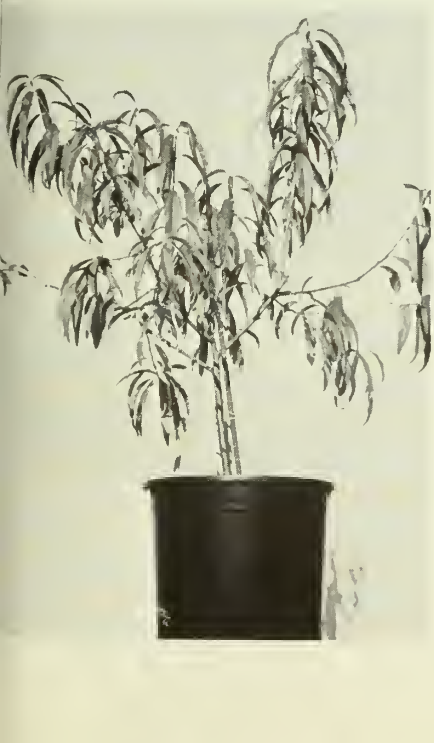

Figure 7. Patio peach tree from cutting after one summer in a 5-gal container.

Fruit Production on Patio Peach Trees

Seven cultivars of own-rooted peach trees in 5-gal containers were selected from the 1980 tests for fruiting in 1981, were placed on an outdoor concrete floor area and were hand watered daily. Excess flowers and fruits beyond what the trees could mature dropped for physiological reasons (Figure 8). Cultivars and dates of the first ripe fruit were Harbrite, McNeely and Princess Anne on June 10; Redhaven on June 26; Sunqueen and Washington on July 3 and Loring on July 15 (Table 7). This represents more than one month of ripe fruit from patio trees of this limited number of cultivars. Yields/tree ranged from an average 0.9 lb for Washington to 4.6 lbs for McNeely. Average diameter of fruits ranged from 2 1/4 to 2 7/8 inches, which is about normal for these cultivars.

This test indicated that patio peach trees from rooted cuttings can be maintained in a healthy condition in 5-gal containers and will form flower buds during the first summer and produce fruit in the second, third and subsequent summers. A dormant tree at the end of the second summer (Figure 9) had many lateral fruit buds on limbs and shoots and produced fruit the next summer.

Trees of six cultivars were maintained in 5-gal containers during the third summer. They were fertilized regularly, were watered adequately and produced their second crop of fruit as a “Patio Peach” (Figure 10). There was a very heavy flower bud set on the trees following the second crop. They were in a good, healthy and vigorous condition, with many fruit buds for their third crop. No pruning was needed during the first and second cro years. Some support was given t weak limbs, by tying them to a iron rod to prevent bending to th ground or breaking from a heav fruit load.

Table 6. The influence of high 20-20-20 supplemental fertilizer applications at weekly intervals on growth of trees from cuttings of 13 peach cultivars in five-gallon containers at Mississippi State University in the summer of 1980.

Cultivar	Trunk circum.	Total canopy volume^y	Total limb growth
	inches	inches^3	inches
Sunqueen	4.3 a^z	20,551 a^z	135 a^z
Rosy Dawn	4.3 a	15,015 b	117 b
Redhaven	3.5 b	9,867 c	104 bc
Princess Anne	3.8 ab	7,453 cd	97 bc
Norman	3.5 ab	6,744 cd	95 bc
McNeely	3.4 b	6,400 cd	94 bc
Loring	3.5 b	6,331 cd	92 bcd
Jefferson	3.1 bc	6,074 cd	91 bcde
Harvester	3.1 bc	5,942 cd	84 bcde
Harken	3.4 b	5,886 cd	70 cde
Harbrite	3.6 ab	4,805 cd	69 cde
Compact Redhaven	3.0 bc	4,532 cd	67 de
Candor	4.0 a	3,242 d	60 e

^{y}Calculated from measurements of height above pot and width of canopy in two directions.

^{z}Means not sharing a common letter differ significantly by Duncan's Multiple Range Test at the 0.5 level.

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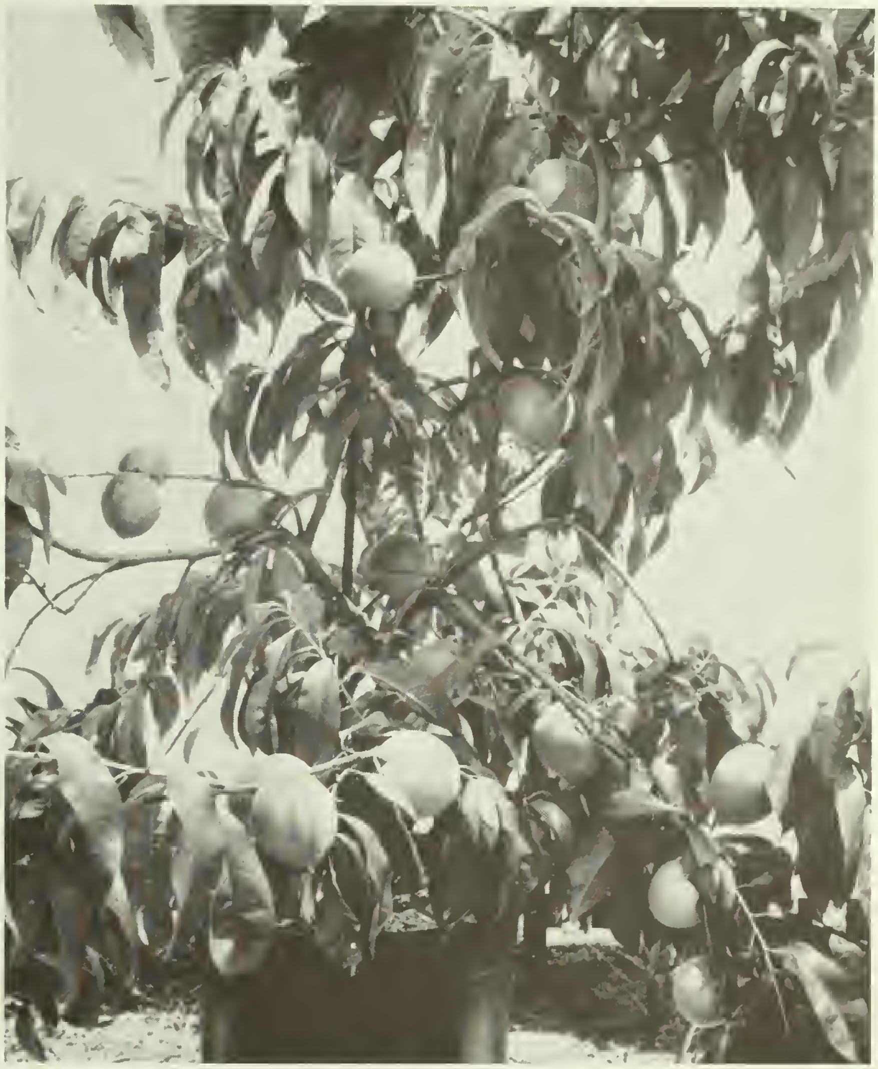

Figure 8. This 2-year-old Princess Anne patio peach tree that produced a fruit crop in June 1981 was propagated from a cutting in August 1979.

Table 7. Yields and dates of harvest of peach trees grown from cuttings, during their second summer (1981) in containers, by cultivar.

Cultivar	Harvest date	Lb/ tree	No. Fr./ tree	Av. Fr. Dia.
Harbrite	June 10	2.1 B*	7.8 BC	2 2/8
Loring	July 15	1.6 B	4.5 BC	2 7/8
McNeely	June 10	4.6 A	16.2 A	2 4/8
Princess Anne	June 10	2.3 B	11.0 AB	2 2/8
Redhaven	June 26	2.2 B	4.2 BC	2 5/8
Sunqueen	July 3	1.3 B	5.2 BC	2 3/8
Washington	July 3	.9 B	2.0 BC	2 5/8

*Numbers not followed by the same letter are significantly different, using the Duncan's Multiple Range Test at .05 level.

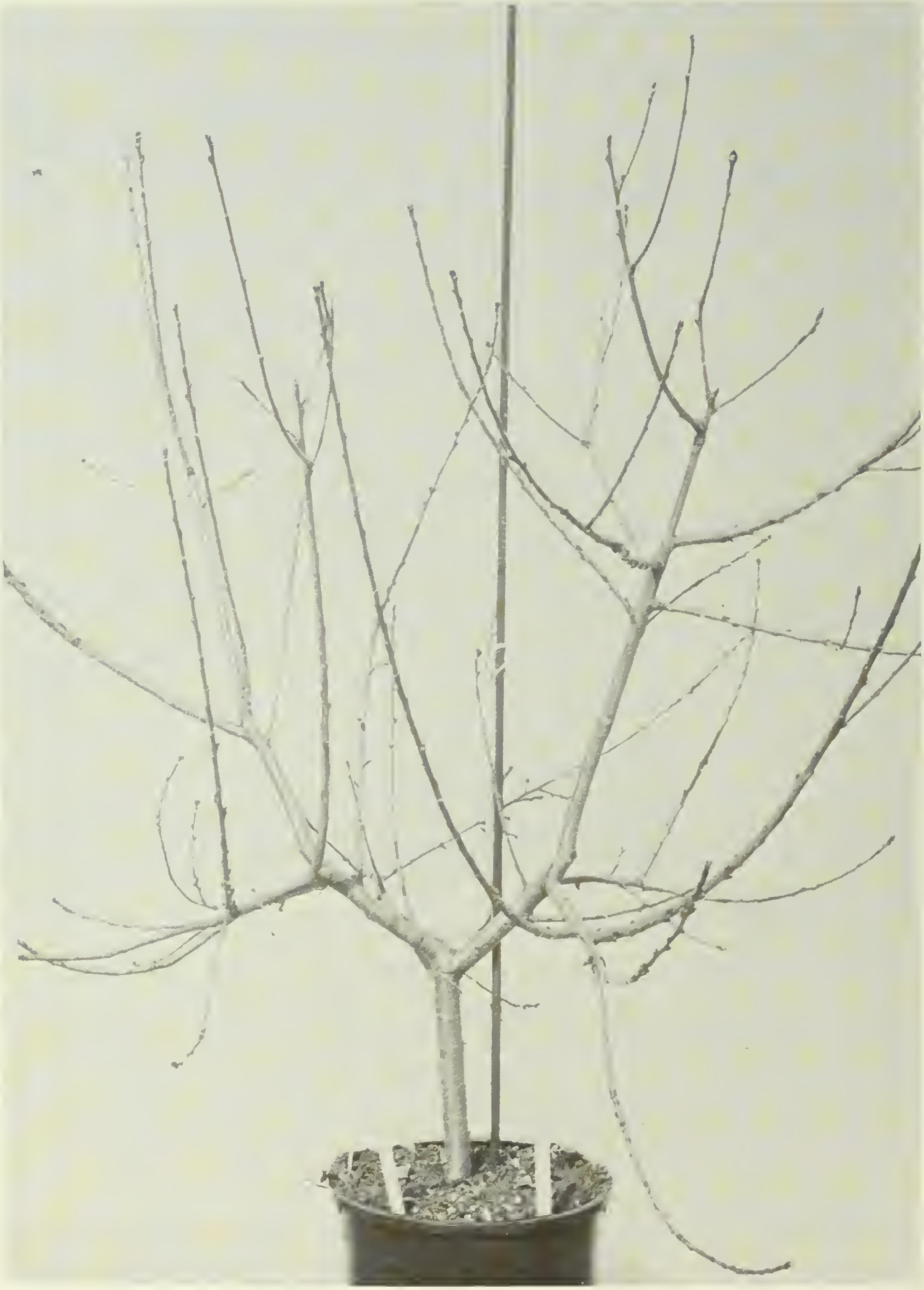

Figure 9. A Patio Peach Tree in February 1982 following two summers in a 5-gal container. This tree was propagated from a leafy cutting that was rooted in August 1979.

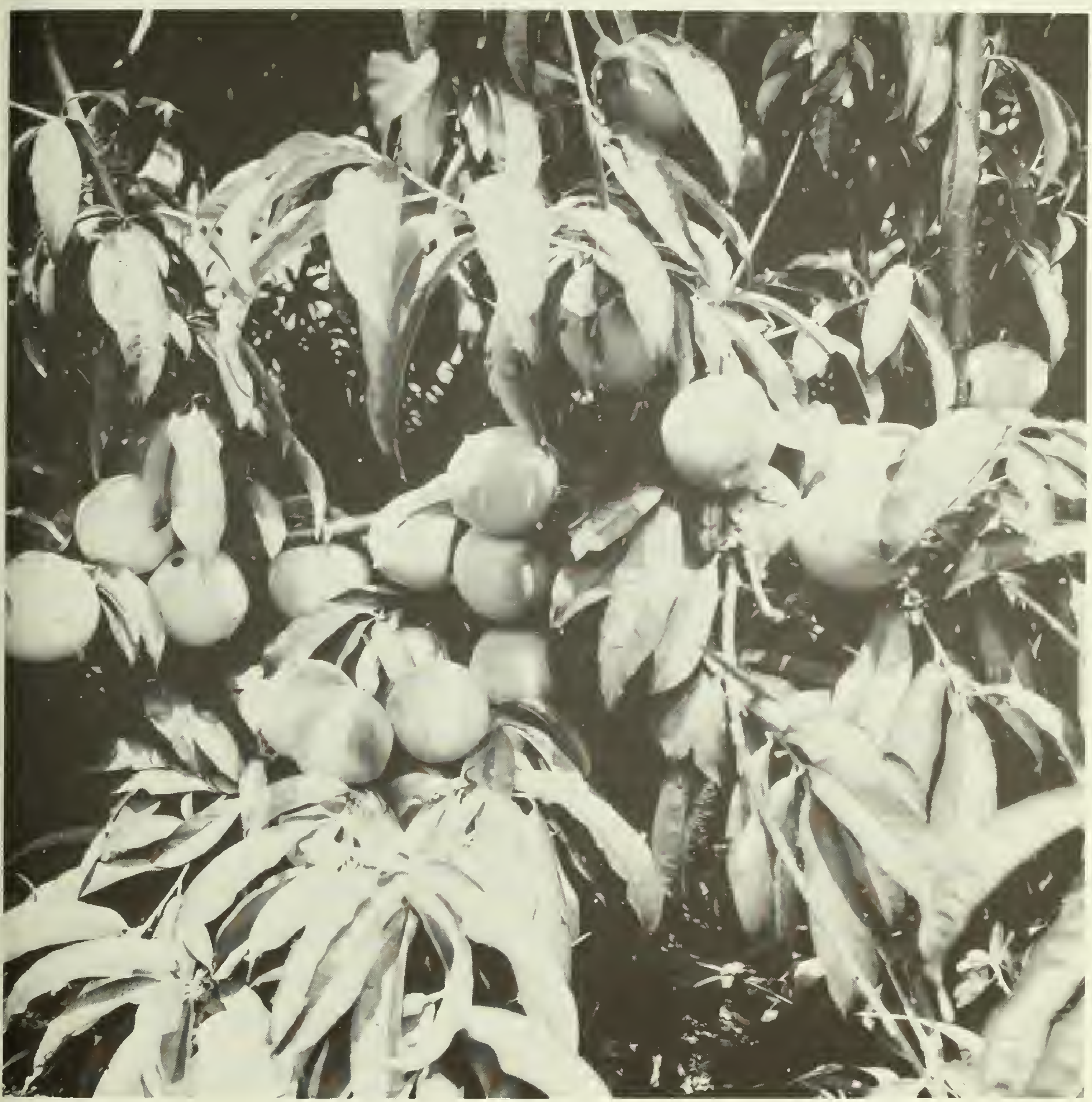

Figure 10. Fruit on a Princess Anne patio peach tree during the second crop year in a 5-gal container.

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January 1983

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Grain Sorghum

Performance Trials 1982

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Mississippi Grain Sorghum Performance Trials 1982

Mississippi Grain Sorghum Performance Trials 1982

Trials are conducted annually in Mississippi to provide farmers, seedsmen, extension personnel and other interested persons with information on performance of commercially available grain sorghum hybrids. Results are particularly helpful to grain sorghum producers in selecting hybrids suited to their area.

We tested 62 commercial and experimental hybrids at six locations in Mississippi in 1982. A good test of performance cannot be made if damaging populations of insects are present; therefore, insecticides were applied as needed. See MAFES Bulletins 817 and 836 for methods of control of insects on grain sorghum.

Resistance to disease is important in selecting a hybrid for areas where diseases are a problem. Also, planting at the recommended time helps reduce damage caused by diseases and insects.

Testing Procedures

A randomized complete block design with three replications was used at all locations. Each plot consisted of two 20 ft-long rows 38 or 40 inches wide. All trials were planted at the rate of 7 lbs of seed per acre. Heads from 13 ft of each plot were hand-harvested, dried and weighed, and yields were calculated using a threshing factor. Yield was adjusted to 14% moisture. Data reported have not been adjusted for bird damage, but trials severely damaged by birds were not harvested. Location of tests, planting dates, fertilizer rates and insecticides applied are presented in Table 1.

Table 1. Planting dates, fertilizer rates (lbs/A) and insecticides applied in Hybrid Grain Sorghum Performance Trials, by location of trials, Mississippi 1982.

Location	Planting Date	Fertilizer Rates[1]	Insecticides applied[2]
Mississippi State	May 14	25-25-85 PP 100-0-0 SD	2-diazinon
Verona	May 18	0-34-68 PP 100-0-0 SD	None
Newton	May 17	65-65-65 PP 66-0-0 SD	None
Holly Springs	May 19	65-65-65 PP	3-Sevin
Raymond	May 20	0-0-60 PP 100-0-0 SD	None
Brooksville	June 8	39-39-39 PP 85-0-0 SD	1-Sevin 1-lannate

[1] SD = sidedressed, PP = Preplant

[2] Insecticides applied as labeled.

Table 2. Performance of 62 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location, 1982.

Hybrid	Brand	50%[1] Bloom (days)	Plant[2] Height (in.)	Seed[3] Mold (rating)	Bird[4] Damage (%)
Savanna 5	N.K.	58	63	1	5
EXP. 8150	N.K.	59	47	2	11
BR 54	(check)	58	62	3	14
B 815	Pioneer	59	55	2	5
G-522 DR	Funk's	59	48	2	19
DK-64	DeKalb	57	52	2	31
G-1516 BR	Funk's	57	53	3	5
M 465	Pfizer	59	48	3	24
R 1090	Paymaster	58	49	3	22
7675	Coker	59	48	2	22
W-744 DR	Warner	58	50	2	5
T-E Dinero	T-E	57	47	3	23
W-839 DR	Warner	58	46	3	22
H 796	Asgrow	57	47	2	19
G-550	Funk's	57	51	3	21
1225 DR	Helena	59	49	2	19
G-1498	Funk's	56	42	2	10
M 990	McCurdy	59	47	2	20
RA 787	Ring Around	57	52	3	24
M 57 YG	McCurdy	59	51	3	32
2670	N.K.	58	53	2	39
DR 1125	Paymaster	59	48	2	24
W-866 A	Warner	58	52	2	18
2660	N.K.	58	48	3	20
DR 1075	Paymaster	57	49	2	28
W-832	Warner	54	49	3	9
G-522 A	Funk's	58	45	3	18
HT-126	Hunt	58	49	3	20
M 572 G	Pfizer	59	51	2	31
DK-64a	DeKalb	58	54	2	31
X 8072	Pioneer	58	47	2	26
8311	Pioneer	58	46	2	20
1330 DR	Helena	58	57	2	35
DK-59	DeKalb	60	50	2	29
RA 808 GB	Ring Around	58	49	3	26
8222	Pioneer	59	47	2	15
W-851 DR	Warner	60	51	2	20
2300	N.K.	56	44	2	10
T-E Y-77	T-E	59	50	3	29
350 DMG	Crop Seed	56	50	2	16
2244	N.K.	56	44	2	19
1330	Wilstar	58	58	3	43

(continued)

(continued)

Table 2. Performance of 62 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location, 1982.

Hybrid	Brand	50% Bloom[1] (days)	Plant Height[2] (in.)	Seed Mold[3] (rating)	Bird Damage[4] (%)
8303	Pioneer	57	48	2	27
G-611	Funk's	58	48	2	20
7638	Coker	57	43	3	20
M 568 G	Pfizer	57	42	2	20
HT-656 BR	Hunt	59	52	2	1
G-1701	Funk's	62	51	2	7
M 737	McCurdy	57	45	2	14
Topaz	Asgrow	58	50	2	17
HT-128 GDR	Hunt	58	47	3	24
BC 162	Crop Seed	56	44	3	18
X 8071	Pioneer	59	51	3	30
Colt	Asgrow	60	51	3	41
Mustang	Asgrow	57	45	2	21
RA 733 GB	Ring Around	58	44	4	17
7723	Coker	58	59	3	38
7623	Coker	56	52	3	38
DK-42y	DeKalb	57	50	3	21
7655	Coker	54	50	3	29
HW-5521	Funk's	55	48	2	36
Corral	Asgrow	54	50	2	49
	Mean	57	49	2.4	22

[1] Average of Holly Springs and Mississippi State.

[2] Average of Newton, Brooksville, Holly Springs and Mississippi State.

[3] Rated at Meridian, MS by Dr. Natale Zummo. Seed mold - 0 = No molded seed, 4 = severe mold and weathering.

[4] Average of Verona, Holly Springs, Brooksville and Mississippi State.

Results

Too few bird-resistant entries were received to permit a separate trial, and both bird-resistant and non-bird-resistant hybrids were tested in one trial at each location. Bird damage was recorded at Mississippi State, Verona, Holly Springs and Brooksville. Damage averaged over these locations ranged from 1 to 49% (Table 2). Bird damage at Mississippi State averaged 9% with a range of 0 to 27%. The average at Verona was 20% with a range of 0 to 43%, the Holly Springs average was 18% with a range of 0 to 73%, and the Brooksville average was 40% with a range of 3 to 65%.

Lodging was negligible at all locations

Grain yield of the 62 hybrids ranged from 1089 lbs/acre for Coker 7623 in the Holly Springs trial to 6262 lbs/acre for Paymaster R 1090 in the Raymond trial (Table 3). Yields averaged over all locations ranged from 2225 lbs/acre for Asgrow Corral to 4287 lbs/acre for N.K. Savanna 5.

Quantity of harvested good-quality grain (or silage) is the best guide to the desirability of sorghum hybrids; however, performance data for any one year may be misleading. Therefore, the two- and three-year average yields of hybrids that have been evaluated for these periods of time are presented (Tables 4 and 5).

Table 3. Yield of 62 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrids and location, 1982

Hybrid	Brand	Yield						
		Miss. State	Verona	Newton	Holly Springs	Raymond	Brooksville	Mean
		lbs. acre						
Savanna 5	N. K.	4107	4420	4685	3732	6045	2735	4287
EXP. 8150	N. K.	5045	4876	4512	2686	5671	2773	4261
BR 54	(check)	4869	3597	4530	4951	5054	2454	4243
B 815	Pioneer	4560	4059	4518	4051	5959	2242	4232
G-522 DR	Funk's	5039	4153	3828	4501	5834	2005	4227
DK-64	Dekalb	3974	4209	4506	3398	5303	3918	4218
G-1516 BR	Funk's	5064	4025	3268	4864	5393	2610	4204
M 465	Pfizer	4762	4192	3399	3368	5329	4000	4175
R 1090	Paymaster	5007	4142	3732	3761	6262	1966	4145
7675	Coker	5140	4248	3851	3383	5646	2072	4057
W-744 DR	Warner	4371	3981	3238	4864	5338	2496	4048
Dinero	T-E	4535	3870	2929	5358	4910	2624	4038
W-839 DR	Warner	4936	3892	3149	4254	5862	2023	4024
H 796	Asgrow	4346	3514	3679	5067	5538	1882	4004
G-550	Funk's	4705	3764	3524	4094	4809	2864	3960
1225 DR	Helena	5310	3697	3286	3282	5938	2136	3941
G-1498	Funk's	5159	3552	3310	3296	5563	2460	3890
M 990	McCurdy	4837	4081	3149	2991	5499	2588	3858
RA 787	Ring Around	4541	3697	3262	3311	5223	2981	3836
M57 YG	McCurdy	4378	3297	3929	3223	5715	2433	3829
2670	N.K.	4604	3909	3369	2483	4377	3819	3760
DR 1125	Paymaster	4541	3814	3179	3746	5482	1751	3752
W-866A	Warner	3244	3280	4345	4095	5096	2454	3752
2660	N.K.	5152	3725	4125	3035	4954	1527	3749
DR 1075	Paymaster	4485	3925	3143	3456	5432	2051	3749
W-832	Warner	3313	4075	4030	3572	5219	2249	3743
G-522A	Funk's	5007	3920	3839	2555	5407	1712	3740
HT-126	Hunt	4737	3586	3399	4167	5150	1379	3736
M572 G	Pfizer	4434	3992	3601	3354	5261	1740	3730
DK-64a	Dekalb	4264	3136	3935	3630	5270	2093	3721
X 8072	Pioneer	4548	3225	3214	3659	5383	2256	3714
8311	Pioneer	4012	3392	4048	2846	5803	2157	3710
1330 DR	Helena	4724	3770	3536	3557	4212	2440	3707
DK-59	Dekalb	5165	3553	3173	2439	4470	3423	3704
RA 808 GB	Ring Around	4094	2535	3423	3107	5618	3381	3693
8222	Pioneer	4837	3330	3292	2672	5895	1987	3669
W-851 DR	Warner	4403	3920	3988	2715	4603	2377	3668
2300	N.K.	4441	3514	3137	3688	4572	2645	3666
T-E Y-77	T-E	4050	3414	3703	3485	5282	1959	3649
350 DMG	Crop Seed	3370	3525	4173	3136	4963	2744	3647
2244	N.K.	4063	3247	2994	3354	4562	3522	3624
1330	Wilstar	3370	3836	3744	2585	5419	2787	3624
8303	Pioneer	4371	3147	3316	3674	5093	2129	3622
G-611	Funk's	4894	3380	3060	3223	4910	2214	3614
7638	Coker	4019	3419	3643	3441	5314	1627	3577
M 568 G	Pfizer	3697	2635	3262	3804	5088	2964	3575
HT-656 BR	Hunt	3162	3425	4101	2962	5729	2039	3570
G-1701	Funk's	4812	3964	2375	3354	5125	1726	3559
M 737	McCurdy	3949	2530	2619	3543	5158	3537	3556
Topaz	Asgrow	3748	3553	1929	4254	5244	2490	3536
HT-128 GDR	Hunt	4195	3764	3203	2817	5813	1372	3527
BC 162	Crop Seed	3804	3041	3369	3586	5197	2100	3516
X 8071	Pioneer	5020	2936	3649	3485	5687	3020	3513
Colt	Asgrow	4403	2852	2899	2715	4116	2659	3441
Mustang	Asgrow	3502	2658	2643	4254	5244	2490	3536
RA 733 GB	Ring Around	4132	3086	3274	3732	4591	1358	3362
7723	Coker	3653	3770	3697	2236	4474	2334	3361
7623	Coker	4831	3375	2250	1089	4924	3034	3251
DK-42y	Dekalb	3508	3108	2369	3282	4319	2440	3171
7655	Coker	3886	2947	2411	2919	3188	2737	3015
HW-5521	Funk's	4119	2274	1435	2875	4040	1986	2789
Corral	Asgrow	3382	2041	2042	1583	2672	1627	2225
	Mean	4365	3545	3407	3429	5153	2406	3712
	LSD(.05)	154	156	244	375	253	357	—
	CV	3.1%	12.3%	19.9%	30.5%	13.7%	41.4%	--

Table 4. Two year average (1981-82) of 23 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location of trials.

		Yield					
Hybrid	Brand	Miss. State	Verona	Newton	Holly Springs	Raymond	Mean
		lbs./acre					
Savanna 5	N.K.	5380	4091	3440	2768	5055	4147
B 815	Pioneer	4864	3791	3353	3375	5086	4094
G-522 DR	Funk's	5493	3358	3024	3483	4840	4040
R 1090	Paymaster	5179	3625	2613	3127	5093	3927
2660	N.K.	5262	3727	2858	2667	4591	3894
W-839	Warner	5221	3530	2281	3310	5058	3880
7675	Coker	5311	3612	2725	2893	4797	3868
Dinero	T-E	4723	3216	2415	3869	4317	3708
W-744 DR	Warner	4805	3269	2566	3351	4323	3663
G-522 A	Funk's	5164	3175	2903	2351	4690	3657
DK-64	Dekalb	4766	2887	3082	2722	4722	3636
8303	Pioneer	5028	3120	2405	3083	4225	3572
7638	Coker	4459	3330	3038	2565	4449	3568
HT 128 GDR	Hunt	4700	3516	2581	2201	4766	3553
W 851 DR	Warner	4775	3079	3226	2097	4573	3550
HT 126 DR	Hunt	4757	3019	2748	3105	4100	3549
1330 DR	Helena	5027	3028	2511	3006	3950	3504
G-611	Funk's	5175	3090	2187	2643	4299	3479
2670	N.K.	4899	3607	2435	2303	4122	3473
DK-59	Dekalb	5379	3257	2272	2166	4048	3424
8311	Pioneer	4292	2996	2820	2305	4518	3386
7623	Coker	4985	3059	1966	1397	4375	3156
DK-42y	Dekalb	4326	2711	2205	2557	3855	3131
	Mean	4971	3308	2681	2754	4515	3503

Table 5. Three year average (1980-82) yield of 11 grain sorghum hybrids in Mississippi Grain Sorghum Performance Trials, by hybrid and location of trials.

		Yield				
Hybrid	Brand	Miss. State	Verona	Newton	Raymond	Mean
Savanna 5	N.K.	4828	4201	3524	5760	4578
G-522A	Funk's	5051	---	2930	5617	4533
B 815	Pioneer	4836	3904	3369	5748	4464
7675	Coker	5074	---	2668	5544	4429
DK-64	Dekalb	4180	---	3563	5515	4419
G-522 DR	Funk's	5163	3389	2839	5802	4298
Dinero	T-E	4574	---	2608	5397	4193
G-611	Funk's	4809	---	2389	5187	4128
7638	Coker	4030	---	3037	5290	4119
2670	N.K.	4408	---	2739	4926	4024
8311	Pioneer	4011	3130	2920	5352	3853
	Mean	4633	3656	2962	5467	4276

Hybrids designated for entry in the 1982 Mississippi Grain Sorghum Performance Trials by sponsors.

Hybrid	Brand	Company	Address
Corral	Asgrow	Asgrow Seed Company	Kalamazoo, MI
Mustang	Asgrow		
Topaz	Asgrow		
H 796	Asgrow		
Colt	Asgrow		
7723	Coker	Coker's Pedigreed Seed Company	Hartsville, SC
7675	Coker		
7638	Coker		
7623	Coker		
7605	Coker		
BC 162	Crop Seed	Crop Seed, Inc.	Lubbock, TX
BC 350 DMG	Crop Seed		
DK-59	DeKalb	DeKalb Ag. Research, Inc.	Lubbock, TX
DK-64	DeKalb		
DK-42y	DeKalb		
DK-64a	DeKalb		
G-522 DR	Funk's	Funk Seeds International	Alexandria, LA
G-611	Funk's		
G-522 A	Funk's		
G-1701	Funk's		
G-550	Funk's		
G-1498	Funk's		
HW 5521	Funk's		
G-1516 BR	Funk's		
1330 DR	Helena	Helena Chemical Co.	Memphis, TN
1225 DR	Helena		
1330	Wilstar		
HT-126 DR	Hunt-Terra	Hunt-Terra Seeds, Inc.	Lubbock, TX
HT-656 BR	Hunt-Terra		
HT-128 GDR	Hunt-Terra		
M737	McCurdy	McCurdy Seed Company	Fremont, IA
M57 YG	McCurdy		
M990	McCurdy		
Savanna 5	N.K.	Northrup King, Co.	Columbus, MS
2660	N.K.		
2670	N.K.		
2300	N.K.		
2244	N.K.		
Exp. 8150	N.K.		
DR 1125	Paymaster	Paymaster Seeds	Plainview, TX
DR 1075	Paymaster		
R 1090	Paymaster		
M565	Pfizer	Pfizer Genetics	Mason City, IL
M572 G	Pfizer		
M568 G	Pfizer		
B 815	Pioneer	Pioneer Hi-Bred International, Inc.	Tipton, IN
8303	Pioneer		
8311	Pioneer		
8222	Pioneer		
X8071	Pioneer		
X8072	Pioneer		
733 GB	RA	Ring Around Products, Inc.	Montomgery, AL
808 GB	RA		
787	RA		
Dinero	T-E	Taylor-Evans Seed Co.	Tulia, TX
Y-77	T-E		
W-851 DR	Warner	George Warner Seed Co., Inc.	Hereford, TX
W-839 DR	Warner		
W-744 DR	Warner		
W-866 A	Warner		
W-832	Warner		

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SOUTHERN PINE BEETLE: THE HOST DIMENSION

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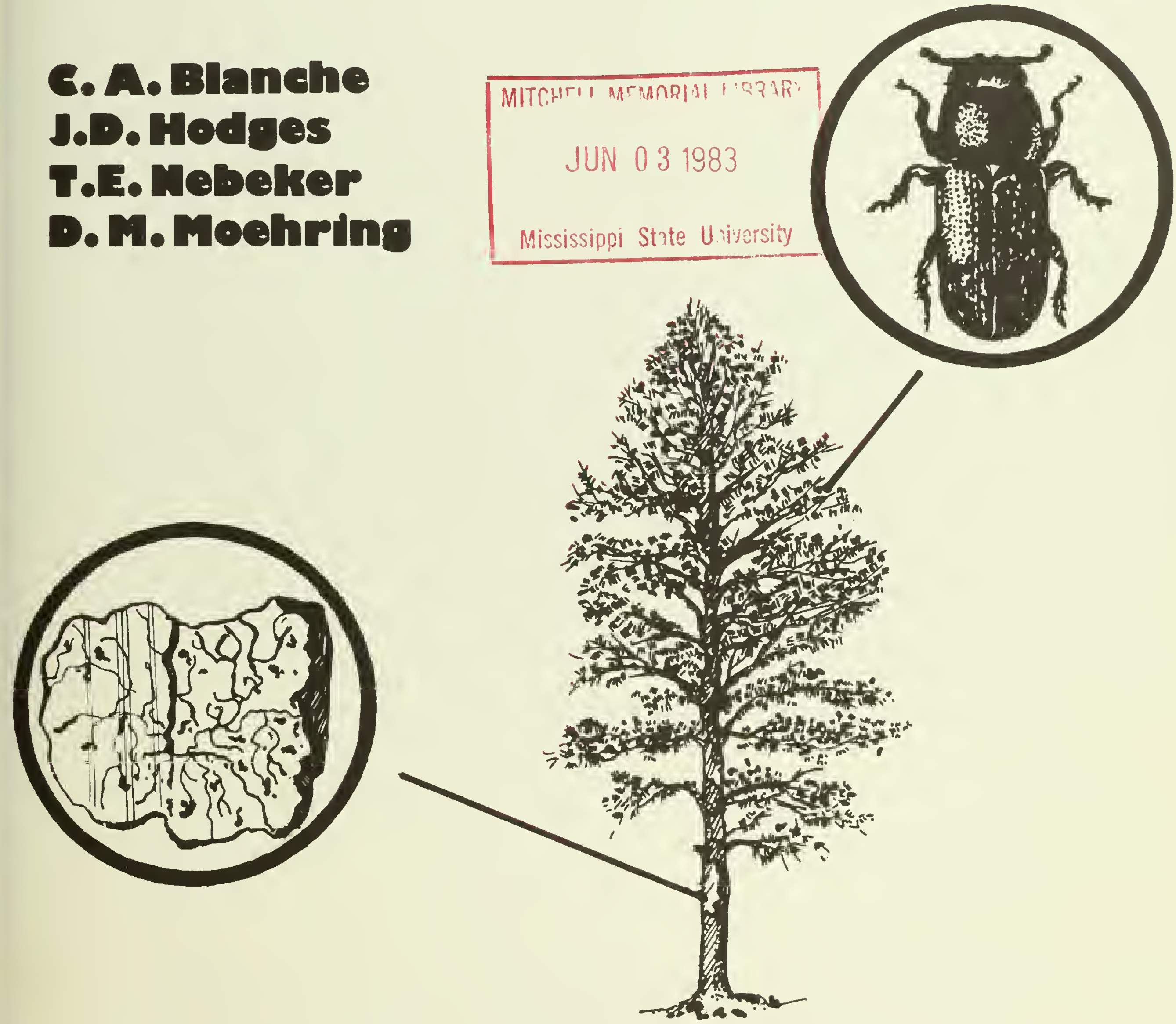

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SOUTHERN PINE BEETLE: THE HOST DIMENSION

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SOUTHERN PINE BEETLE: THE HOST DIMENSION

INTRODUCTION

The southern pine beetle (SPB), *ndroctonus frontalis* Zimmer- ann (Coleoptera: Scolytidae) is nsidered one of the most serious sts of southern pines. The first tbreak formally recorded in the uthern United States occurred ring 1882 in southeast Texas opkins, 1903). Since then, in- tations have recurred extensive- spreading to areas roughly nciding with the geographic stribution of loblolly pine (*Pinus eda* L.). A historic account of ese outbreaks has been compiled Price and Doggett (1978) for the utheastern United States.

Comprehensive reviews on this etle were done by Thatcher 960), Dixon and Osgood (1961) d Coulson et al (1972). An in- grated presentation edited by atcher et al (1980) covered the e history and habits (Payne, 80), natural enemies and sociated organisms (Berisford, 80), climatic, site and stand ctors (Hicks, 1980), population dynamics (Coulson, 1980), sampling and predicting population trends (Hain, 1980), impacts of the SPB (Leuschner, 1980) rating of stands for susceptibility (Lorio, 1980), silvicultural guidelines for reducing losses (Belanger, 1980), direct control (Billings, 1980) and integrated management strategies (Coster, 1980). Intensive treatment of the host as it influences the SPB is non-existent, except for the initial efforts of McAndrews (1926) and Caird (1935). Hanover (1975) reviewed the physiology of tree resistance to insects with some emphasis on the mechanisms of resistance and host terpene physiology but with little reference to the SPB. This review is therefore aimed at consolidating scattered host-related information, particularly the physiological aspect, analyzing and synthesizing such information and identifying knowledge gaps with the ultimate objective of prioritizing research on the host-bark beetle relationship.

The review was done in a combined time sequence and topical organization approach. In other situations the approach was dictated by developmental logic.

In analyzing the literature we used the following terms as defined:

Susceptibility = degree of resistance of the host to insect colonization. We visualize resistance as a spectrum with one extreme described as susceptible and the other extreme as immune.

Suitability = host quality in relation to brood development and resultant brood quality.

Vigor = the overall state of the host as reflected in the different degrees of metabolic activities (synthetic and degradative processes). Radial growth is one example of a manifestation of the degree of synthetic processes.

Attractiveness = the quality of the host that draws the beetles to attack or go near.

HOSTS AND HOST CHARACTERISTICS

osts

The SPB can potentially attack d kill all pine species within its nge (St. George and Beal, 1929; xon and Osgood, 1961). Payne 80) suggested that loblolly pine so highly preferred that the ographic distribution of the SPB roughly approximated by the stribution of this pine species. wever, in the three geographic gions of the South (Coastal Plain, edmont and Southern Ap- lachians), shortleaf pine (*P. inata* Mill.) has been reported be the most susceptible, while loblolly pine is the other most susceptible species in the Coastal Plain (Belanger and Malac, 1980). In Arkansas, shortleaf pine is the preferred host (Ku et al, 1980), probably because of its abundance. In the Georgia Piedmont, shortleaf pine is again the preferred host despite the fact that it is not the most abundant pine species in the area (Belanger et al, 1977). This latter preference for shortleaf pine has been attributed to the predisposing effect of littleleaf disease (Belanger et al, 1979). In the southern Appalachians, shortleaf and pitch (*P. rigida* Mill.) pines are the preferred hosts (Belanger and Malac, 1980; Belanger and Hatchell, 1981) with pitch pine considered more susceptible (Belanger et al, 1979). In another report, Kowal (1960) cited shortleaf, loblolly and Virginia (*P. virginiana* Mill.) pines as the preferred hosts, and slash (*P. elliotti* Engel.), longleaf (*P. palustris* Mill.) and spruce (*P. glabra* Walt.) pines as the less desirable hosts. Earlier, St. George and Beal (1929) reported loblolly and shortleaf pine to be much more susceptible than longleaf and slash pine.

The apparent preference for specific host species appears to be related to variation in oleoresin properties. In comparing the four major southern pines (loblolly, longleaf, slash and shortleaf), Hodges et al (1977, 1979) identified total resin flow as the most discriminating variable in classifying the least desirable (most resistant) host. Belanger et al (1979) observed that white pine (*P. strobus* L.) was the least preferred host in the southern Appalachians and this has been attributed to the ability of this species to "pitch out" the SPB.

To test if there was any preference for loblolly over shortleaf pine, Thomas et al (1981) assayed for biting responses of SPB to bark extracts of different polarities. Judging from the bioassay responses, there seems to be no preference for loblolly over shortleaf. However, when inner bark and outer bark extracts were separated, extracts from the outer bark of shortleaf pine elicited the greatest number of biting responses. In loblolly pine, White (1981) demonstrated, through a bioassay, that diethyl ether and methanol extracts of inner and outer bark influenced beetle tunneling. The positive and negative responses of SPB to the bark extractives were attributed to tree-to-tree variation in extractive concentrations. White viewed these positive and negative responses as indicative of responses to gustatory stimulants and deterrents.

Other coniferous species reported to be occasional hosts of SPB in the United States are table mountain pine (*P. pungens* Lamb.) (Knull, 1934), red spruce (*Picea rubens* Sarg.) (Payne, 1980), pond pine (*P. serotina* Michx.) (Payne, 1980) and ponderosa pine (*P. ponderosa* Dougl. ex Laws.) (Wood, 1963).

Table 1. Comparison of the four major southern pines.

Features	Longleaf Pine	Slash Pine	Shortleaf Pine	Loblolly Pine
Turpentine density[1]	0.8618	0.8533	0.8452	0.8525
Turpentine index of refraction[1]	1.4657	1.4631	1.4728	1.4700
Optical rotation of turpentine[1]	+7.89°	-30.78°	+103.49°	+46.2°
% turpentine from oleoresin[1]	22-23	22	16-20	14-19
d, dl α-pinene[1] (%) (based on turpentine)	64	75	85	71
l- β-pinene[1] (%) (based on turpentine)	31	21	11	22
Oleoresin viscosity[2] (stokes)	60	306	24	18
Total flow (ml)[2]	18	11	9	12
Rate of flow (ml/hr)[2]	1.55	0.56	0.78	1.12
Flow at 8 hrs. (%)[2]	66	38	67	77
Time to initial crystallization (hrs)[2]	0.98	48	2.36	0.98
α-pinene (mg/100mg oleoresin)[3]	21.18	16.44	14.30	16.56
Camphene (mg/100mg oleoresin)[3]	0.18	0.22	0.18	0.20
Myrcene (mg/100mg oleoresin)[3]	0.70	0.48	0.60	1.56
β-pinene (mg/100mg oleoresin)[3]	5.23	4.22	12.06	8.58
Limonene (mg/100mg oleoresin)[3]	0.49	0.25	0.93	1.68
β-phellandrene	0.22	2.86	0.90	1.04
Total monoterpene (mg/100mg oleoresin)[3]	28.00	24.47	28.96	29.63
Pimaric acid (mg/100mg oleoresin)[3]	3.79	3.76	3.77	5.11
S.C. Pimaric acid (mg/100mg oleoresin)[3]	1.11	1.09	1.19	1.22
Palustric acid (mg/100mg)[3]	12.21	15.10	8.40	12.18
Levopimaric acid (mg/100mg)[3]	16.83	8.62	18.74	19.44
Isopimaric acid (mg/100mg)[3]	10.98	17.40	10.05	7.15

(continued)

There are no reports to indicate that outbreaks have occurred in these occasional hosts.

SPB outbreaks in Central America have occurred in the following pine species as hosts: *P. oocarpa* Schiede (Coyne and Critchfield, 1974), *P. caribaea* Morelet (Coyne and Critchfield, 1974), *P. pringlei* Shaw (Hendricks, 1977 as cited by Payne, 1980) and *P. pseudostrobus teocate* Lindl. (Hendricks, 1977 as cited by Payne, 1980). The broad range of host species attests to the aggressive behavior of this species.

Host Characteristics: Comparison of the Four Major Southern Pines

Motivated by our desire to explore the possibilities of identifying relevant host characteristics for breeding and rating resistance of individual trees and stands to SPB attack, we have tabulated species characteristics of the four major southern pines (Table 1). We premised our characterization on the recognition that slash and longleaf pine are more resistant, and shortleaf and loblolly pine are more susceptible to SPB attack. A cursory look at the table provides no significantly consistent feature for the four species, except for oleoresin viscosity, which stands out as a possible distinguishing characteristic for resistance.

Table 1. (continued)

Features	Longleaf Pine	Slash Pine	Shortleaf Pine	Loblolly Pine
Abietic acid (mg/100mg)[3]	8.08	8.57	7.95	8.63
Dehydroabietic (mg/100mg)[3]	3.76	2.67	4.20	3.82
Neoabietic acid (mg/100mg)[3]	11.61	13.75	10.85	9.49
Total resin acids (mg/100mg oleoresin)[3]	68.37	70.96	65.15	67.04
Radial resin duct width (u)[4]	57.6	54.8	49.0	54.6
No. of resin ducts[4]	32.6	43.9	35.5	35.3
Oleoresin viscosity (stokes)[4]	55.7	241.0	20.9	16.2
Resin flow rate (ml/hr)[4]	1.1	0.6	0.8	1.5
Most critical disease[5]	brown spot	fusiform rust	littleleaf disease	fusiform rust

[1] Mirov, 1961.

[2] Hodges et al., 1977.

[3] Hodges et al., 1979.

[4] Hodges et al., 1981.

[5] Dorman, 1976.

HOST RESISTANCE/ SUSCEPTIBILITY TO SPB

What Constitutes Host Resistance to SPB?

The preference for a particular host is a valid manifestation of resistance. When a particular host species is preferred at one location and not in another it indicates that induced resistance or pseudoresistance exists. Our discussion of resistance of southern pines to SPB does not distinguish between induced resistance and inherited resistance. Suffice it to say that host resistance to SPB exists.

Any effective investigation of host resistance to insect pests must recognize the components of resistance. The resistance components according to Painter (1951) are *preference* or *non-preference, tolerance* and *antibiosis.* Indications from the literature show tolerance to play no important role in host resistance to SPB. The preference or non-preference component appears likely. Field observations of host preferences, the attractiveness of loblolly and shortleaf pine over longleaf and slash pine and the result of the biting response bioassay of Thomas et al (1981) tend to support this general cause of host resistance to SPB. Although tree-killing bark beetles apparently use both random and directed host selection (Wood, 1982), decisive studies leading to the identification of the basis for host selection are lacking (Cates and Alexander, 1982). For as long as the question of host selection remains unresolved, our understanding of host resistance to SPB will continue to between trees. Rates of soil moisture depletion are considerably reduced in thinned shortleaf pine stands. This slowdown in water use prolongs available soil moisture for extended seasonal growth (McClurkin, 1961). The same pattern has been observed in thinned pine plantations in other places. For instance, a thinned 39-year-old red pine (*P. resinosa* Ait.) plantation in lower Michigan exhibited increased diameter growth, and the initial supply of moisture was available for a longer period of time (Della-Bianca and Dils, 1960). In the West, Helvey (1975) reported that heavy thinning of a 50-year old ponderosa pine stand resulted in a radical reduction in soil moisture depletion, but growth was greatest in stands thinned to a 15-foot spacing (moderate thinning). In New Zealand, dense stands of Monterey pine (*P. radiata* D. Don) exhausted available soil moisture as early as November, and diameter growth stopped. Moisture was available in heavily thinned stands, and diameter growth continued until the following March or April (Butcher and Havel, 1976). In the same investigation, Butcher and Havel (1976) claimed that moisture limitations manifest themselves first in depression of diameter growth, second in predisposition to attack by *I. grandicollis*, and third in direct drought deaths.

It has been claimed that the immediate effect of thinning is to increase light levels in the bottom one third of the crown, providing a wider zone of high photosynthetic surface and increased production by older needles (Woodman, 1976). His light measurements at different heights along the crown showed that only 2% of full sunlight reached the needles on the bottom branches of 37-year old unthinned Douglas fir (*Pseudotsuga menziesii* (Mirb. Franco) trees. A correlation analysis indicated that almost all photosynthetic variations on the bottom one third of the crown were accounted for by radiation. However, other microclimatic factors, such as ambient air temperatures, vapor pressures and ambient CO_2 concentrations, play more significant roles in the upper crown. The paper further asserted that the secondary effect of thinning is to increase transpiration rates and nutrient uptake. This increase in transpiration rate is on an individual tree basis and should be compensated for by fewer numbers of trees utilizing the water supply.

Mason (1971) reported that the average OEF was 40% greater in loblolly pines in thinned plots than in trees in unthinned plantations. This should not be construed as a direct effect of thinning in enhancing OEF but rather the effect of eliminating individuals with low OEF. Overstocking in the stand was found to reduce OEF rates more than temporary moisture stress did (Mason, 1971). This is not surprising since flow rate is more a function of oleoresin reservoir (Hodges et al, 1977). And Schopmeyer and Larson (1955) have shown that oleoresin production is influenced by dbh, crown size, and position of trees in slash pine stands.

Under Excessive Moisture

Effects of Excessive Moisture on the SPB

Too much moisture could be beneficial or detrimental to the SPB depending on its stage of development. Craighead (1925) observed that heavy precipitation, while the young broods were developing under the bark, caused high mortality. He also noted that heavy precipitation effectively killed the beetles during periods of attack. He then concluded that excessive precipitation is one of the causes of rapid decline of SPB epidemics. Beal (1927), corroborating Craighead's observations, found heavy brood mortality of SPB in 1926-27 in Asheville, NC to be due to excessive rain in the fall of 1926 and high temperatures in January. On the other hand, regression analysis revealed that excessive moisture appeared to favor the reproduction and rapid development of SPB broods as expressed by the regression coefficients of the two moisture variables used (Kalkstein, 1976). Integrating excessive rainfall with season, Kroll and Reeves (1978) showed that periods of high summer rainfall were correlated with increased numbers of spots, while high spring and fall rainfall were correlated with reduced beetle activity. (More on this under host conditions in relation to brood development.)

Effect on the Host and Host Characteristics

The overall effect of excessive moisture on SPB hosts was expressed by Hetrick (1949) when he wrote "the most susceptible hosts are pines weakened by excessive precipitation." The key point in this statement is that tree vigor is influenced by surplus moisture, and not tree growth since drought is more effective than flooding in reducing cross-sectional growth of loblolly pines (Lorio and Hodges, 1968). Despite the slower radial growth of pines in dry or droughty conditions, trees growing in wet or waterlogged soils are more susceptible to beetle attack (Hicks et al, 1979). Reduced vigor of trees growing along Kerr Reservoir in North Carolina was believed to be due to periodic flooding (Hicks, 1980; Maki et al, 1981). Lorio (1968) reported that pines growing on poorly drained sites are particularly susceptible to SPB attack. Kalkstein (1976, 1981), in his attempt to identify significant climatic variables associated with SPB outbreaks, suggested that the vigor of loblolly pine is adversely inuenced by moisture surplus since e areas under study are often aterlogged.

Why are loblolly pines that are bjected to flooding more lnerable to SPB attack than ose under droughty conditions? e do not fully understand this enomenon, but we do know that

a) flooding significantly reduces the bark-water potential of loblolly pine just as drought does (Hodges and Lorio, 1969);
b) continuous flooding adversely affects both OEP and relative water content of loblolly pine (Lorio and Hodges, 1968);
c) flooding noticeably reduces the rate of growth of conifer terminals (Ahlgren and Hansen, 1957);
d) flooding increases the mortality of secondary roots (Hosner, 1959);
e) loblolly pine growing on flat or concave sites (periodically waterlogged) have fewer fine roots than those on comparable trees on mounds (Lorio, Howe and Martin, 1972);
f) loblolly pine subjected to continuous flooding exhibits a remarkable increase in sugars, but the increase occurs later relative to sugar increase in drought stressed trees (Hodges and Lorio, 1969);
g) under anaerobic conditions, the roots of many species produce compounds such as ethanol and acetaldehyde (Fulton and Erikson, 1964), ethylene (Kawasi, 1972) and cyanogenic compounds (Rowe and Catlin, 1972);
h) summer flooding is more injurious to woody plants because oxygen is less soluble at higher temperatures (Verentennikov, 1964);
i) under flooded conditions, transpiration is much lower (McColl, 1973; Veretennikov, 1964), but trees on moist soils are capable of increased transpiration activity when their root systems are not completely flooded (Veretennikov, 1964);
j) under temporary cessation of respiration (due to anaerobiosis) plant cells lose a significant portion of their water, and the water retaining ability of the leaves drops (as reviewed by Samuilov, 1965);
k) flooding increases the glycolytic rate of intolerant trees (Crawford and McMannon, 1968);
l) glycerol accumulates in the roots under flooded conditions (Crawford, 1976) and
m) OEP is high in the early morning in all control and drought-stressed trees, but flooded trees exhibit low pressures as well as the drastic and prolonged reduction in OEP all day (Lorio and Hodges, 1968).

This last observation (m) is interesting in that it appears to implicate OEP in the greater susceptibility of flooded trees than drought-stressed trees.

Effects of Flooding on the Soil and Microorganisms

A knowledge of the effects of flooding on soil provides us better insight into the SPB/host interaction since these effects are eventually translated into host and finally into beetle response (survival). We know that flooding causes oxygen deficiency. Very often anaerobiosis may develop within a few hours after flooding due to displacement of gas from the soil pore space (Coutts and Armstrong, 1976). Under such reduced conditions, phosphorus availability usually increases but nitrogen availability is diminished (Patrick, 1978). Ahlgren and Hansen (1957) pointed out that the soil carbon dioxide-oxygen ratio and nitrate availability are altered by flooding and that such alterations may cause growth retardation. Waterlogged soils have been known to produce harmful substances such as sulphides (Culbert and Ford, 1972), high CO_2 concentration (Hook et al, 1971) and soluble iron and manganese (Jones, 1972). The production of hydrogen sulphide (H_2S) brought about by the reducing conditions in soils may not only affect the host trees but may attract the beetles. All and Anderson (1974) have shown that pioneer beetles of *I. grandicollis* are attracted to such odors as carbon disulfide (foul odor).

Mycorrhizal fungi do not grow anaerobically (Coutts and Armstrong 1976). Under flooded conditions, the mycorrhizal association may be entirely absent. Mycorrhizal surface area appears to be related to water regime. When the soil becomes drier, mycorrhizal surface area is reduced on mounds and increases on flats. The surface area is greatly reduced on flat sites during most of the wetter period (Lorio et al, 1972). The forms of mycorrhizae also appear to change with soil moisture conditions. The nodular types become common when there is excessive soil moisture, and the bifurcate and branched types predominate under moisture stress (Lorio et al, 1972).

Lightning-struck Trees

Lightning and Extent of Damage

Lightning is a very powerful change agent in a forest ecosystem. It starts forest fires, acts as a nitrogen fixer and predisposes trees to other agents of deterioration (Taylor, 1969, 1971, 1974). A lightning bolt can produce as many as 345,000 amperes of electricity (Anonymous, 1966) and can develop peak color temperatures of the channel in air from 21,000° to 31,000°K (Prueitt, 1963; Uman, 1964). Although very little is known about the peak temperature developed by a lightning discharge at the ground level, it is believed to develop energy sufficient to melt some metals and to ignite forest fuels (Taylor, 1969). Coupled with these energy characteristics is its frequency; it is estimated that about 8 million lightning discharges strike the earth each day, and if these were evenly distributed, roughly half a million would be striking the world's forests (Taylor, 1969).

Lightning damage has been reported in the swamp forests of Southeast Asia (Anderson, 1964; Brunig, 1964), the rubber plantations of Sumatra (LaRue, 1922), the banana plantations of Honduras (Reinking, 1930), the Valdivian rain forest of Chile (Wilhelm, 1968), the Trans-Saharan regions of Africa (Phillips, 1965), the radiata pine stands in Australia (Minko, 1966), the forests of Scotland (Murray, 1958) and the coniferous forests of the U. S., particularly the western states (Taylor, 1969). Forest wildfires could be the most destructive direct effect of lightning on the temperate coniferous forests of North America. Each year, lightning causes some 10,000 forest and range fires in the U. S. alone (Fuquay et al, 1967). Timber mortality caused by lightning probably ranks second in severity. Ffolliott and Barger (1967) examined 634 sawtimber trees in northern Arizona and found 10% of these to have been damaged by lightning. Johnson (1966a) claimed that lightning was responsible for 4% of the mortality of old-growth ponderosa pines in western Montana. Reporting from the northeastern U.S., Nelson (1958) found that lightning caused 25% mortality of 1,300 mature eastern hemlock trees. From the South, Trousdell (1955) indicated that lightning was one of the most important single causes of mortality of loblolly pine seed trees.

Lightning that strikes the forest does not necessarily cause a wildfire, but often causes structural damage to the struck tree. Occasionally, such damage extends to a nearby tree (Schmitz and Taylor, 1969). Structural damage ranges from the removal of the cambium or sapwood (Fuquay et al, 1967; Taylor, 1969; Hodges and Pickard, 1971) to splitting and ejection of slabs from the most severely damaged trees (Fuquay et al 1967; Taylor, 1969). Loosening of bark of struck trees has been observed in loblolly pine (Howe et al, 1971). Severance of lateral roots (Minko, 1966; Schmitz and Taylor, 1969), exposure of main roots (St. George, 1930) and excavation of the soil at the base of the lightning scar (Schmitz and Taylor, 1969) have likewise been reported. Crown injuries, in the form of ruptured branchlets and needles, by flying bark and wood debris (Taylor, 1969) and ignition of crown foliage and upper stem (Fuquay et al, 1967) are common in lightning-struck ponderosa pine. Sometimes, a struck tree literally explodes (Johnson, 1966b) causing its virtual disappearance. It appears that all parts of a tree are vulnerable to lightning injury.

Attractiveness of Lightning-struck Trees to Bark Beetles

Conifers that are structurally damaged by lightning are very attractive to bark beetles (Hopkins, 1909; St. George, 1930; Knull, 1934; Beal and Massey, 1945; Hetrick 1949; Thatcher, 1960; Anderson 1960; McMullen and Atkins, 1962; Rudinsky, 1962; Thatcher and Pickard, 1964; Johnson, 1966b; Anderson and Anderson, 1968; Schmitz and Taylor, 1969; Hodges and Pickard, 1971; Howe, et al, 1971; Lorio and Bennett, 1974; Lorio and Yandle, 1978). Johnson (1966b) reported that about 80% of all mature ponderosa pine struck by lightning were attacked and killed by the western pine beetle. Of the 2,100 SPB infestations over a three-year period in south-central Louisiana, 31% were associated with lightning-struck trees, and 75% of the beetle spots found in August alone of those years ha lightning-struck trees (Hodges an Pickard, 1971).

Studying the spatial-tempora distribution of SPB infestations near Oakdale, Louisiana, Lorio and Bennett (1974) found that lightning was associated with 29% of the infestations tallied from April, 1965 to March, 1969. And in August 1965 alone, 77% of the infestations included lightning struck trees. Available information indicates that lightning plays a very important role in the SPB population dynamics. In late summer and early fall, when beetle populations are normally low (Thatcher and Pickard, 1964), lightning-associated infestations peak (Lorio and Bennett, 1974; Lorio and Yandle, 1978). A southwide survey of SPB-infested plots showed that 39.0%, 31.6% and 23.0% of the attacked plots in Arkansas, Texas and Georgia, respectively, contained lightning struck trees as opposed to 0.4%, 0.9%, and 1.0% of the corresponding non-attacked plots (Hicks, 1980). Also, trees around a struck tree often become vulnerable. For instance, a study by Schmitz and Taylor (1969) revealed that 76% of the ponderosa pine trees within an 80-foot radius of the struck tree were infested by the pine engraver (*I. pini* Say) in the upper two-thirds of the stem, with some mountain pine beetle at 50 feet and western pine beetle in the lower 20 feet. Whether such increased susceptibility of neighboring trees is directly attributable to lightning is uncertain. However, reports of declining trees around struck stems have been published (Jackson, 1940; Murray, 1958; Anderson 1964; Komarek, 1964; Minko, 1966b). Schmitz and Taylor (1969) suggested that lightning causes unobserved physiological injury to trees surrounding a struck tree, making them susceptible to beetle attack.

What makes a struck tree highly

attractive to bark beetles is not fully understood, but hypotheses have been stated as follows:

a) Fermentation of the phloem, whether by anaerobic respiration or from external microorganisms, could be a product of the wounding of ponderosa pine trees by lightning. Volatile odors from this fermented phloem attract newly emerged beetle adults (Johnson, 1966b);
b) When lightning strikes a pine tree and ruptures the bark, certain host volatiles are released from the exposed wood and phloem. Some of these volatiles are attractive to *Ips* spp. flying through the forest (Anderson and Anderson, 1968);
c) The sudden release of ozone following a lightning strike attracts beetles (Howe et al, 1971);
d) Microorganisms invading a lightning wound produce beetle attractants (Howe et al, 1971);
e) The black turpentine beetle may respond to an attractant(s), produced as a result of the strike, and in turn produce a secondary attractant responsible for attack by the SPB (Hodges and Pickard, 1971);
f) The ejection and deposition of the debris shower from the struck tree on neighboring trees provide a means for short-term oleoresin release that enhances the probability of discovery and attack by pioneer beetles in an otherwise marginal olfactory search situation (Taylor, 1974).

Vité and Gara (1962) and Howe, et al (1971) presented convincing evidence against hypotheses *a* and *d*. Both studies concluded that microorganisms do not have a role in the initial attraction of the SPB to struck trees. However, Howe, et al (1971) stressed that the microorganisms may play a major role in modifying the condition of trees and enhancing their suitability for brood development. Hypothesis *b* appears promising. For instance, Werner (1972) demonstrated that *I. grandicollis* is attracted to volatile terpenes released from host tree phloem. All and Anderson (1974), working on the same species of bark beetle, provided further support for the hypothesis that *I. grandicollis* initially selects and attacks host trees as a chemotactic response to olfactory stimuli. The initial attack by SPB was hypothesized to be in response to volatiles emitted by dead pines (Heikkenen, 1977). Heikkenen's data were collected in an area of endemic beetle populations. The problem with hypothesis *b* is the difficulty of designing a decisive experiment to test it. To date no experiment has ever attempted to collect volatilized compounds from a lightning struck tree. The other complication is the pheromone produced by the first beetles attacking a struck tree. At this point, the issue of host selection as being random or directed inevitably causes argument between individuals. Whether pioneer beetles attack a host tree in a random manner (Vité, 1961; Vité and Wood, 1961; Gara, Vité and Cramer, 1965; Franklin, 1970; Berryman and Ashraf, 1970; Howe et al, 1971; Hynum and Berryman, 1980; Moeck et al, 1981) or initial attacks result from attraction to odors emanating from susceptible host trees (Person, 1931; Anderson, 1948; Chapman, 1963; Rudinsky, 1966; Heikkenen and Hrutfiord, 1965; All and Anderson, 1974; Heikkenen, 1977) remains unresolved. There is no doubt that host selection by the SPB is extremely complicated and very likely species specific. However, it is possible that host selection is a catenary process (Kennedy, 1965). At the ecosystem level, it is the arrestant property of pine trees that holds the SPB from getting outside its host range. At the individual tree level, it is the distribution, duration, and concentration of potential host attractant(s) that provides a sphere of influence that directs the SPB to its susceptible host. After a successful initial attack, a stronger secondary attraction (pheromone effect) leads to mass attack. Therefore, the host selection catena for SPB may be composed of orthokinesis (host finding movement with an arrestant), olfactory, biting and gustatory responses. Hypothesis *c* at first appears attractive (Howe et al, 1971), but observations in north Florida, strongly suggest that ozone produced by lightning strikes is at best insignificant, and even declines regardless of intensity and severity of the lightning activity (Davis, 1974). Hypothesis *e* proposes that the black turpentine beetle responds to a primary (host) attractant, produced as a result of the strike, and in turn produces a secondary attractant responsible for the attack by the SPB (Hodges and Pickard, 1971). This hypothesis is based on the observation, by the same authors, that the black turpentine beetle usually attacks first, *I. grandicollis* and SPB at about the same time and *I. avulsus* last. Merkel (1981) also noted that pines attacked by the black turpentine beetle are subsequently attacked by other bark beetles. Furthermore, the black turpentine beetle exhibits a strong preference for wounded trees, which provide strong initial attractancy for the pioneer beetles (Goldman, Cleveland and Parker, 1979). The attraction of black turpentine beetles to oleoresin liberated by lightning strikes was observed earlier (Hopkins, 1909). Vité et al (1964) demonstrated that black turpentine beetles respond to uninfested log sections and to various resinous compounds. Also, the possibility of beetles of one species being attracted by the aggregation pheromone of another species (Vité et al, 1964) is worth considering. Hypothesis *f* is the same as hypothesis *b* except that a means of oleoresin release and distribution is specified. This hypothesis also attempts to explain the "group kill" associated with lightning strikes.

Chemical and Physiological Changes in Struck Trees

Reports on the chemical and physiological changes in lightning-struck trees are scarce. The suggestion by Johnson (1966b) that fermentation of the phloem by anaerobic respiration or by external microorganisms occurring as a result of wounding by lightning has never been validated.

The water relations of lightning-struck trees have been shown to be markedly altered (Anderson and Anderson, 1968; Hodges and Pickard, 1971). The relative water content of the inner bark of struck loblolly pines is much lower than in green trees, and the difference increases with time (Hodges and Pickard, 1971). Anderson and Anderson (1968) found that the hydrostatic condition of the struck trees deteriorated first in the crown and progressed gradually down the stem. Since the turgor of the epithelial cells regulates the OEP (Vité and Rudinsky, 1962), a reduction in hydrostatic pressure is accompanied by a decrease in OEP. Hodges and Pickard (1971) reported that the average OEP for control trees was 7.7 atm. as against 2.3 atm. and 0.4 atm. on the undamaged and damaged sides of struck loblolly pines, respectively. Concommittant with the reduction in OEP was the reduction in OER. Anderson and Anderson (1968) obtained OER values ranging from 0 to 0.9 ml/hr for a struck loblolly pine, with the lowest values occurring nearest to the lightning-caused fissure. Their data on the water content of the inner bark did not show any direct effect upon *Ips* attacks or brood development, except in cases of extreme water loss.

The chemistry of lightning-struck trees and subsequent changes with time have not been adequately investigated. Some changes in reducing and non-reducing sugars, starch (Hodges and Pickard, 1971), amino N and total N (Smith, 1968; Hodges and Pickard, 1971) have been reported. Amino N and total N were little influenced by lightning strikes (Hodges and Pickard, 1971), but with time, total N increased while amino N decreased (Smith, 1968). Smith (1968) attributed this increase in total N to microorganisms colonizing the lightning wounds. Howe et al (1971) isolated and identified microorganisms from lightning wounds. In addition, Bridges (1978) isolated nitrogen-fixing bacteria from *D. frontalis, D. terebrans, I. avulsus* and *I. calligraphus*. After these beetles attacked struck trees, total N increased while amino N decreased (Hodges and Pickard, 1971). Whether the increase in total N and decrease in amino N were due to attack or would have happened anyway is uncertain. However, a closer look at Smith's data (Smith, 1968, Tables 3 and 4, pp. 18 and 19) indicates some increase in total N and decrease in amino N even before attack took place.

Lightning strikes apparently cause marked reduction in non-reducing sugar, which is further reduced after beetle attack. The reducing sugar is increased by the strike slightly over the control (Hodges and Pickard, 1971). The starch level is unaffected by the strike but declines slightly after the beetles have attacked. Other chemical changes (e.g., volatilization of terpenoids, oxidation of monoterpene compounds, electrolysis of water) which may play some role in host selection, have not been examined.

The effect of lightning is subsequently reflected in the growth of the tree as loss in increment and volume (Wadsworth, 1943). All things being equal, most of the lightning-struck trees die sooner than non-struck trees (Baker, 1974).

Role in Brood Development and Population Dynamics

Apparently, lightning renders a tree favorable for brood development and survival. To wit, the breeding potential of *D. brevicomis* was estimated to be greater in lightning struck ponderosa pines than in living ponderosa pines that were normally attacked (Johnson, 1966b). For example, the mean number of emergence holes in struck trees was estimated to be from 150 to 200/ft^{2} of bark as against a mean of 63 holes/ft^{2} in normal host trees. With *D. frontalis*, a record emergence of 950 beetles/ft^{2} was estimated in a struck tree as against an average emergence of 250/ft^{2} in unstruck infested trees (Hodges and Pickard, 1971). This increased suitability of struck trees may be attributed to lower resinosis (Berryman, 1976), greater amounts of available energy substrates and other essentials for insect growth and development, since lightning-struck trees are often the largest and most vigorous individuals in a stand. Also, the reduction of the relative water content of the inner bark improves the brood environment of the beetles. Although Anderson and Anderson (1968) claimed that the moisture content of the inner bark did not have a direct effect on brood development of *Ips* spp., the moisture content of their experimental tree did not go below 100%. Earlier, Anderson (1948) pointed out that heavy brood mortality of *Ips* occurred when bark moisture content was below 100%. Anderson and Anderson (1968) attributed the successful brood development of *Ips* in a lightning-struck tree to a markedly reduced OER. Despite limited data, Hodges and Pickard (1971) demonstrated a positive correlation between SPB emergence and carbohydrate content of struck trees. Earlier, it was indicated that hexose sugars were more readily utilized by the SPB (Barras and Hodges, 1969).

The attractiveness of lightning-struck trees to beetle attack and their suitability for brood development may play a major role in the dynamics of SPB populations. Struck trees have not only served as centers for spot infestations (Lorio and Bennett, 1974) but have sustained beetle populations during periods of low seasonal activity (Hodges and Pickard, 1971). It is apparent that the effect of lightning is more pronounced during endemic periods and generally masked during epidemics.

Under Biotic Stress (Diseases and Other Pests)

The association of root injury due to microorganisms and other agents with increased attractiveness to SPB attack was first pointed out by Hetrick (1949). He asserted that any disturbances that interfere with the normal functioning of the root systems of pines may induce bark beetle attack. His observation of the mushroom root rot (*Armillaria mellea*) on SPB-infested trees clearly indicated that the fungus preceded the bark beetle attack. The attractiveness of flooded and lightning-struck pines, as described earlier in this paper, lends support to this claim.

Root pathogens play some role in predisposing southern pines to SPB attack. Lorio (1966) reported that *Phytophthora cinnamomi* Rands. and *Pythium spp.* were associated with declining 40-year old loblolly pines in the lower Gulf Coastal Plain of Louisiana. Observations on Monterey pine by Hartigan (1964) indicated that root destruction by *Phytophthora cinnamomi* and other organisms may predispose trees to insect attack. Prolonged wet conditions on flat sites (common in the lower Gulf Coastal Plain) are believed to favor the distribution and development of rootlet pathogens (Lorio and Hodges, 1971). Pines on intermound areas have been observed to form rough bark on roots, and this has been associated with phloem starvation due to impeded synthesis or translocation of food by root diseases (Jackson and Hepting, 1964). The dynamics of mycorrhizal associations (abundance and types) in these flat sites and mounds (Lorio, et al, 1972) may find some value in the maintenance of tree vigor. Mycorrhizal roots have been shown to be resistant to certain pathogens (Marx, 1967; Marx and Davey, 1969; Zak, 1964). Very recently, the vesicular-arbuscular mycorrhizal fungi have been pointed out to affect plant parasitic nematodes by physiologically altering or reducing root exudates responsible for chemotactic attraction of nematodes or directly retarding nematode development or reproduction within the root tissue (Hussey and Roncadori, 1982).

In the Georgia Piedmont, littleleaf disease has been implicated as an agent predisposing shortleaf pine to beetle attack (Belanger et al, 1977). A study of this disease by Copeland (1952) indicated that mortality of roots less than one-fourth inch in diameter contributes to the rapid decline of shortleaf pine. Also, when 18 to 34% of the roots are infected, normal growth stops and the tree declines very rapidly.

Under certain conditions, particularly on the Coastal Plain, annosus root rot (*Heterobasidion annosum* (Fr.) Bret.) is an important predisposer of pines to SPB attack in thinned loblolly pine stands (Alexander, 1977; Alexander et al, 1978; Alexander et al, 1980). This is very true on high-hazard annosus root rot sites, but not in low-hazard sites such as the Piedmont (Belanger, 1981). Skelly (1976) found that about 30% of the roots of SPB-attacked trees had annosus root rot infection compared with 20% for unattacked trees. In an extensive survey of the Coastal Plain, Skelly et al (1981) and Alexander et al (1981) noted that annosus root rot is significantly associated with trees infested by the SPB. The same studies suggested that the disease stressed the SPB-attacked trees as indicated by reduced mean annual radial growth in the last 5-10 years. Kuhlman (1970) identified isolates of annosus root rot with varying degrees of virulence, hence causing different degrees of infection of living pine roots and, in turn, varying effects on tree growth (Bradford and Skelly, 1976).

Aside from these pathogenic organisms, other pests may initiate the decline of the host. Lorio (1973) suggested that black turpentine beetle may contribute indirectly to SPB epidemics by weakening trees and rendering them more attractive to other beetles. Lorio and Hodges (1977) observed black turpentine beetles attacking their flooded and drought-stressed trees before they could induce SPB attacks.

In most instances, these biotic factors act in concert with environmental factors so that their true effects are hard to isolate. Regardless of how they affect the trees, the obvious consequence is the alteration of normal host metabolism resulting in reduced growth and vigor.

Other Stress Forms (Harvesting, Wind, Fire, Etc.)

Any stress that causes elastic or plastic strain is bound to alter the normal physiology of the host. Unfortunately, we know very little about host physiology under stress due to harvesting, thinning, wind, ice, etc. However, we do know that above- and below-ground injuries from harvesting and thinning operations serve as infection courts for organisms causing decay and discoloration. In fact, thinning increases the incidence of annosus root rot on deep sandy sites underlain with clay (Powers and Verrall, 1962; Froelich et al, 1977). Other stress forms, such as windthrow (St. George, 1930; Knull, 1934), recent fire (Knull, 1934) and logging disturbance (Ku et al, 1976; Porterfield and Rowell, 1981), have been associated with SPB outbreaks. In some areas, however, fire has never been associated with SPB infestation (Ku et al, 1980). Between water-stressed and wounded trees, the wounded ones tend to be attacked more frequently by the SPB (Brown and Michael, 1978).

We need more thorough investigations of these stress-causing influences as they affect SPB population dynamics. Studies geared towards cause-and-effect relationships should have high priority.

HOST PHYSIOLOGY AND CONDITIONS IN RELATION TO BROOD DEVELOPMENT

Requirements for Brood Development

The food and microenvironmental requirements for SPB brood development have received little attention. We do not yet have a good handle on its nutritional needs. Initial attempts at mass rearing, providing a number of nutritional compounds, met with a limited success (Clark and Osgood, 1964). Mott et al (1978) aseptically reared SPB from egg to adult on 3% nutrient agar with loblolly pine callus initiated on Brown and Lawrence nutrient medium. When they added β -sitosterol to the medium, adult production increased from 14 to 26% of hatched larvae. It is intuitively obvious, though, that in nature, the two basic brood requirements of the beetle are a bark which serves as a habitat and substrate and a favorable environment. The environment can have a direct effect on brood development and survival of the beetle or an indirect one through its effect on the host. The bark offers the best medium for establishing the nutritional requirement (qualitatively) through chemical characterization. Such bark chemical characterization must be guided by established knowledge of nutritional requirements necessary for insect growth such as that given by Dadd (1970, 1973) and Hagen (1974) as follows:

1. water
2. minerals (salts)
3. 10 essential amino acids
4. 7 to 10 water soluble vitamins
5. vitamin C
6. a sterol
7. carbohydrate.

The water, amino acid and carbohydrate components of the bark have been investigated (Gaumer and Gara, 1967; Hodges et al, 1968; Lorio and Hodges, 1968; Barras and Hodges, 1969; Hodges and Lorio, 1969; Hodges and Pickard, 1971; Lorio and Hodges, 1977; Webb and Franklin, 1978; Wagner, et al, 1979). The other nutritional components have not received any research attention.

Host Conditions Affecting Brood Development and Mortality

The larval stage is a critical period in the life of the SPB. In fact, larval mortality is greater than mortality in any of the other life stages (Coulson et al, 1976; Goldman and Franklin, 1977; Wagner et al, 1979). Since the larval stages are primarily spent in the inner bark and with a short time in the outer bark for pupation, host conditions in the inner bark must have a strong influence on the development and survival of the brood. For instance, the high mortality (70.7%) from egg to the first and second larval instars could be attributed to host-tree conditions, since there are so few predators and parasites associated with these first two instars (Goldman and Franklin, 1977). Anderson (1948) obtained the best brood survival with pine engraver when the inner-bark moisture content did not deviate much from that found in vigorous trees. He also found that heavy brood mortality occurred when the inner-bark moisture dropped below 100%. Gaumer and Gara (1967) identified an optimum rearing environment for SPB from infested bolts to be from 20 to 22°C and RH of 50 to 60%---conditions that approximate the natural events occuring in infested trees. In general, high phloem moisture is associated with the formation of elongate larval mines and reduced survival (Thatcher, 1960; Clark and Osgood, 1964; Webb and Franklin, 1978). The rapid dehydration of the phloem to a moisture content below 200% appears essential to brood survival (Gaumer and Gara, 1967). The importance of this initial decline in moisture content to brood survival has been corroborated by Wagner et al (1979). Anderson (1967) on the other hand, employing techniques of girdling and bark isolation to produce a variety of physiological conditions, observed that the moisture content of the inner bark was not critical to either the success of *Ips* attacks or brood development under his experimental conditions. Anderson and Anderson (1968) concluded that the inner bark moisture content limited *Ips* brood development only where severe dessication occurred.

Investigations on the changes in

moisture status of the tree through time revealed that xylem water potential, xylem moisture and phloem moisture influenced SPB development (Webb and Franklin, 1978; Wagner et al, 1979; Coulson, 1980). Egg and early larval development proceed with xylem and phloem dehydration. As soon as the phloem and xylem moisture approaches the minimum, the larvae migrate to the outer bark, and the rehydration of the phloem takes place at about the time brood adults emerge (Wagner et al, 1979; Coulson, 1980). Webb and Franklin (1978) on the other hand reported an earlier time of phloem rehydration, which occurred about the time the larvae reached the outer bark. This phenomenon of phloem rehydration has not been elucidated. Changes in phloem moisture content elicit varying responses from the different beetle life stages. Wagner et al (1979) demonstrated that eggs and first-stage larvae of SPB are unaffected by changes in phloem moisture, while development of 2nd and 3rd instar larvae is slowed by phloem moisture above 170%. High bark-moisture content also slows the development of 4th instar larvae and pupae.

Environmental stresses are believed to cause chemical changes in the inner bark, which in turn influence the nutritional quality of the tissue. Water stress causes an increase in reducing sugars, which are readily used by the SPB and associated microorganisms (Barras and Hodges, 1969). Using cellular and extra-cellular liquid of bark samples from sound and unhealthy trees of *Picea abies* and *Pinus sylvestris*, Chararas et al, (1960) observed that the rate of development of Scolytidae is closely related to the amount of soluble sugars. Adequate hydration of tree tissues maintains a high level of oleoresin flow which prevents effective egg and larval development (Lorio and Hodges, 1977). Anderson (1967) showed that high OEP, a variable highly correlated with tissue hydration, reduces the suitability of the host tree for *Ips* attack and brood development. Unless the water balance of the tree is disturbed and its OEP reduced to 60 psi, the bark beetles cannot breed successfully (Grossman, 1967).

It is apparent that host suitability for brood development is one of the final determinants of the subsequent population status of SPB with respect to quality and quantity. Unfortunately, host suitability is not a constant property of the host but is related to a number of factors, such as the levels of readily assimilated compounds (Chararas et al, 1960; Hodges et al, 1968; Barras and Hodges 1969; Hodges and Lorio, 1969), rate of tissue dessication (Gaumer and Gara, 1967; Webb and Franklin, 1978; Wagner et al, 1979), initial host vigor (Lorio and Hodges, 1977), inner bark temperature (Gaumer and Gara, 1967; Powell, 1967), host tree species and age (Coulson, 1980), diameter of the host tree (Fargo et al, 1979), presence of microsymbionts (Howe et al, 1971; Barras, 1973) and an array of environmental factors.

HOST-SPB-MICROORGANISMS COMPLEX: THE ROLE OF THE ASSOCIATED MICROORGANISMS

The Beetle-Microorganism Association

The relationship between the SPB and the blue-stain fungi is considered symbiotic, but the demonstration that the beetle can complete its life cycle without the blue-stain fungi (Barras and Bridges, 1976) indicates that the relationship is protocooperative. Grossman and Hamburg (1965) believe that the relationship between bark beetles and the blueing fungi in general is optional. In fact, the absence of the fungi has no effect on the number of attacks, ovipositional gallery length and number of egg niches, but the number of progeny decreases, and the emergence is delayed 13 to 24 days (Barras, 1973). Also, laboratory observations show that the blue-stain fungi are detrimental to SPB development (Barras, 1970; Franklin, 1970). The fungi are thought to reduce the nutritive value of the inner bark and may even be toxic or repellent to larvae and adults (Franklin, 1970). However, the presence of other microorganisms prevents the expression of this detrimental effect (Barras, 1969). The reduction of progeny in SPB in the absence of blue-stain fungi can have greater implications for beetle population status. This reduction can perhaps spell the difference between an endemic population and a population outbreak. Unfortunately, the above studies were conducted on bolts or bark tissues; therefore, the relationships observed between the fungus and the beetle do not necessarily reflect the relationship between them in standing trees.

The blue-stain fungi and some

associated bacteria have some beneficial effects on the beetle. The presence of the mycangial fungi can increase the level of nitrogen compounds for beetle nutrition (Becker, 1971). Bridges (1978) demonstrated the presence of nitrogen-fixing bacteria in the SPB-microorganism association. Comparison of the levels of lipids in the phloem without mycangial fungi with phloem colonized by the fungi shows that lipids increase over time in the fungi-colonized phloem (Berisford, 1980). Kok et al, (1970) suggested sterol metabolism as a basis for mutualistic symbiosis.

From the standpoint of beetle behavior, the mycangial fungi appear to play some regulatory role. Brand et al (1976) showed that mycangial fungi are capable of transforming trans-verbenol to verbenone. Some yeast metabolites have also been shown to enhance the attractiveness of the attractant mixture of frontalin, trans-verbenol and host odor (Brand et al, 1977). A bacterium, *Baccillus cereus*, isolated from southern pine bark beetles is capable of producing verbenol (Brand et al , 1975). A mycangial basidiomycete has been reported to produce isoamyl-alcohol, 6-methyl-5-hepten-2-one and 6-methyl-5-hepten-2-ol (Brand and Barras, 1977).

Effects of the Associated Microorganisms on the Host

The blue-stain fungus (*Ceratocystis minor* (Hedge.) Hunt) is considered the principal tree-killing agent (Coulson, 1980). This claim has not been fully elucidated in SPB infested southern pines. Attempts to verify the role of the fungus have been unsuccessful (Hare, 1969; Brown and Michael, 1978). Earlier investigations, however, implicated the blue-stain fungus in accelerating the death of the beetle-infested host (Caird, 1935; Craighead and St. George, 1938; Bramble and Holst, 1940). How the associated fungi kill the host tree has remained a subject for further investigation. Caird (1935) noted that, after attacks by the bark beetles, the outer rings of shortleaf pine trees lose their capacity to translocate water in the sapwood. He attributed this to the invasion of the vascular elements by the fungi. This was later corroborated by Bramble and Holst (1940). Mathre (1964), using dye indicators, showed that water is conducted around but not through fungal infected areas of the sapwood. He suggested that pathogenecity may involve entry of air into the sapwood. Anderson (1960) suggested several mechanisms by which the associated fungi cause rapid host death. These include

a) toxin production,
b) mycellial plugging of the tracheids,
c) release of gas bubbles into the tracheids and
d) production of particles that block the pit openings by causing tori aspiration.

The study of blue-stain fungi associated with the mountain pine beetle by Shepard and Watson (1959) indicated that the fungi probably reduce stored food in the parenchyma cells and restrict water conduction by destroying the ray parenchyma cells, which partly control water movement. Pathogenecity tests of some blue-stain fungi revealed that stain penetrates into the sapwood and can kill loblolly pine seedlings (Basham, 1968). Dye conduction tests also revealed no dye in stained sapwood. The possibility of toxin production by these associated fungi exists. For instance, the isolation and identification of phenolic metabolites, especially 6, 8-dihydroxy- 3-hydroxymethyl isocoumarin, from *Ceratocystis minor* (McGraw and Hemingway, 1977) appear to support this hypothesis.

Host Response to Invasion by Associated Fungi

Observations of failures of bark beetle colonization are common. These are often attributed to pitch flow. However, the possibility exists that this is due to the failure of the fungi to establish themselves. Kulman (1964), for instance, observed that unsuccessful *Ips* colonization of red pine did not have blue-stain in the wounds. Basham (1970) noted a zone of phenols and resins in the region of fungal invasion of resistant loblolly pine trees but not in trees killed by the fungi. Berryman (1972) reported that resistant trees produce a hypersensitive reaction, causing a wound periderm to form around the necrotic lesion caused by fungal infection. When there is no hypersensitive reaction, the tree may die. The production of polyphenols and other toxic compounds may also serve as a host defense system to *Ceratocystis* infection (Shrimpton, 1973). However, some known toxic compounds such as flavonoids and stilbenes have been shown to be degraded by *Ceratocystis minor* (Hemingway et al, 1977). Therefore, such compounds could not be considered a host resistance factor against *Ceratocystis*.

STATE OF KNOWLEDGE ANALYSIS AND RESEARCH NEEDS

The SPB attacks all pine species within its natural range. The physical properties of the oleoresin system appear to be the primary defense mechanism against attack by this beetle. However, other factors influence this resistance mechanism either directly or indirectly. Hence, the host resistance (R) to SPB may be briefly described as

$$R = f\left(\frac{\text{GR, } O_f\text{, OEP, OER, HR}}{\text{Age, stress, stand BA, beetle density}}\right)$$

where,

Gr = radial growth rate

O = oleoresin quantity

OEP = oleoresin exudation pressure

OER = oleoresin exudation rate

HR = hypersensitive response.

Although some of these variables are expected to be autocorrelated, the above representation is presented as a form of synthesis of the qualitative information we now have on host resistance to SPB. Host physiology and conditions are inextricably intertwined with all these variables. Integrating these variables simplifies the host resistance (R) equation into

$$R = f\frac{\text{vigor}}{\text{beetle density}}$$

Based on current knowledge, the attack process of the SPB is summarized in a flow diagram (Figure 1). The flow diagram emphasizes the importance of the host (susceptibility and suitability) in the attack process. The level of the beetle population is also emphasized, and its interaction with the host is shown in Figure 2. Combining these host variables and the beetle-attack density in a host-by-beetle matrix, the beetle population consequences can be conceptualized as shown in Table 2.

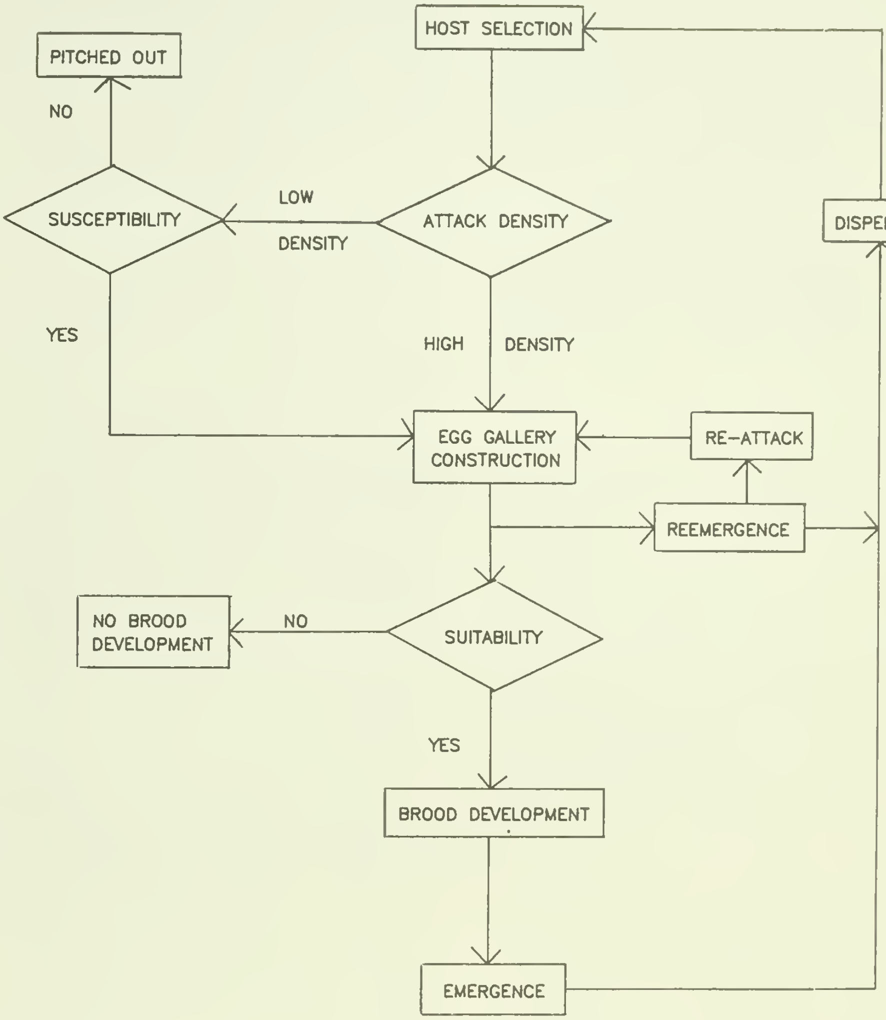

Figure 1. Flow diagram of the southern pine beetle attack process.

The susceptibility/resistance components of the host have been fairly well researched, and a number of relationships have been uncovered. Unfortunately, we do not have the critical values of the variables associated with these relationships to make full use of them. Hence, the establishment of the threshold levels of these variables, such as oleoresin flow, OEP, OER, rate of crystallization, bark or tree water potential, etc., for successful colonization of host to occur, is a high priority need.

The suitability component of the host has not been adequately investigated. We feel this ranks second in research priority since this may finally determine the consequent beetle population.

The beetle-inoculated blue stain fungus, *Ceratocystis minor,* is recognized as the principal tree-killing agent. How the fungus kills the tree is not fully understood. Investigation along this line will not only lead us to a better understanding of the host-SPB-microorganism complex but will provide us with alternative methods of control.

Other aspects of the host that demand investigative attention include:

a) host chemistry and physiology as affected by different forms of stress (excess water, deficient water, logging damage, wind, fire, lightning, disease, etc.);
b) the synchronization of seasonal host physiology with seasonal beetle activity; and
c) the development of host vigor indices.

Table 2. Conceptualization of relationship between host conditions and beetle attack density.

Degree of Resistance	Host Suitability	Beetle Attack Low Density	 High Density
Susceptible	Low	endemic population	population may collapse
	High	may lead to epidemic	explosive
Resistant	Low	endemic, dispersal	endemic, dispersal
	High	endemic but may build-up upon host predisposition	explosive

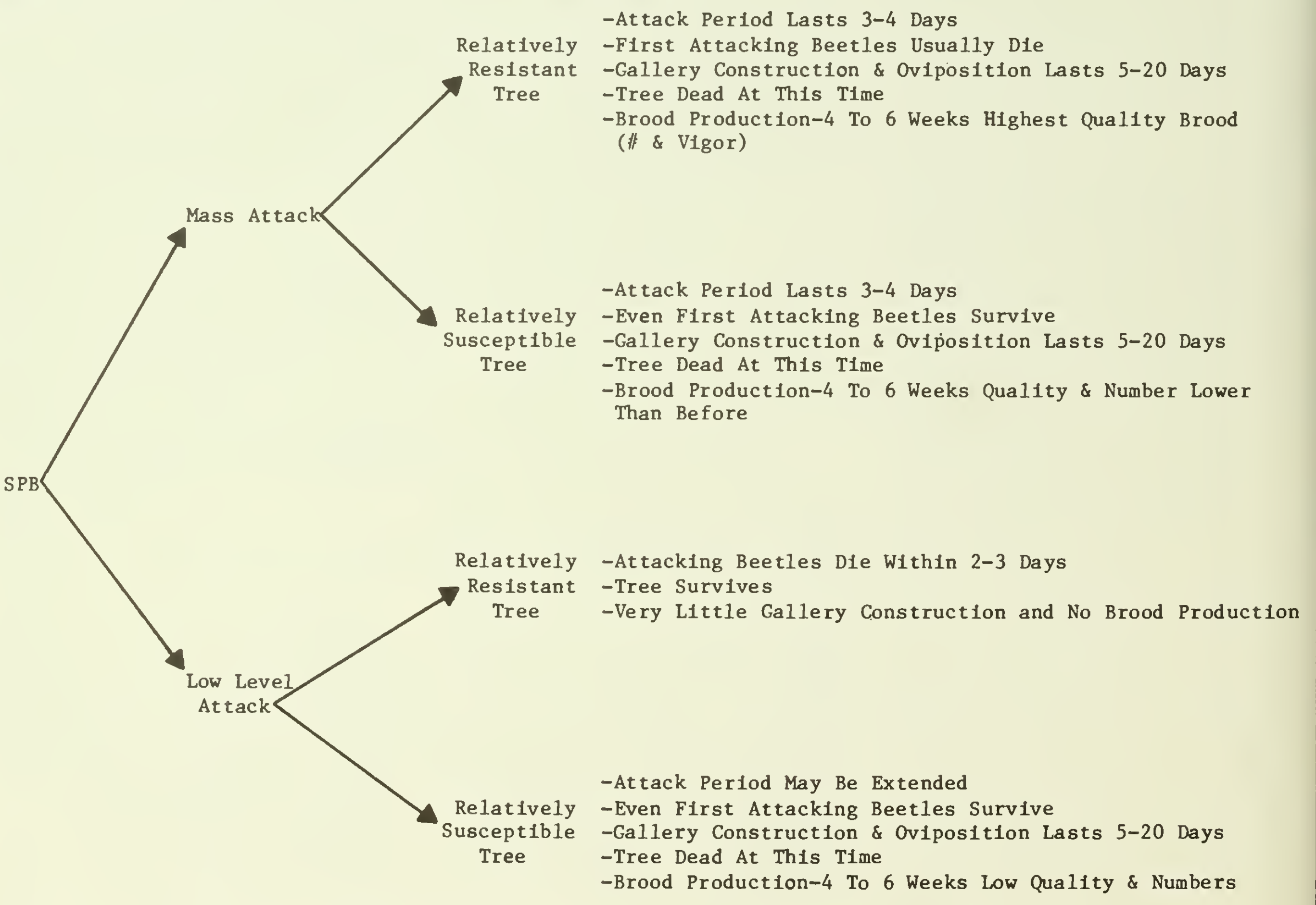
SPB
Mass Attack
Low Level Attack
Relatively Resistant Tree
-Attack Period Lasts 3-4 Days
-First Attacking Beetles Usually Die
-Gallery Construction & Oviposition Lasts 5-20 Days
-Tree Dead At This Time
-Brood Production-4 To 6 Weeks Highest Quality Brood (# & Vigor)
Relatively Susceptible Tree
-Attack Period Lasts 3-4 Days
-Even First Attacking Beetles Survive
-Gallery Construction & Oviposition Lasts 5-20 Days
-Tree Dead At This Time
-Brood Production-4 To 6 Weeks Quality & Number Lower Than Before
Relatively Resistant Tree
-Attacking Beetles Die Within 2-3 Days
-Tree Survives
-Very Little Gallery Construction and No Brood Production
Relatively Susceptible Tree
-Attack Period May Be Extended
-Even First Attacking Beetles Survive
-Gallery Construction & Oviposition Lasts 5-20 Days
-Tree Dead At This Time
-Brood Production-4 To 6 Weeks Low Quality & Numbers

Figure 2. Consequences of southern pine beetle attack density and host resistance interaction.

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Tillage and Weed Control Practices in Soybeans Grown on Sharkey Clay Soil

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Tillage and Weed Control Practices in Soybeans Grown on Sharkey Clay Soil

Summary

Centennial soybeans were grown in 40-inch rows in 1978, 1979 and 1980 on Sharkey clay soil in plots that were either disked (3 to 4 inches deep), chisel plowed (4 to 5 inches deep) or superchisel plowed (7 to 8 inches deep) in the fall or spring before planting and treated with preplant herbicides. Soybean yields were 3.7 to 4.7 bu/acre lower on the spring-chisel or superchisel plowed plots than on plots that were fall or spring disked or fall chiseled in 1979. There were no significant differences in 1978 or 1980. A preplant incorporated fall application of trifluralin + metribuzin at 1.25 + 1.5 lb/acre gave about 12% less control of annual grasses than did preplant spring-applied treatments of paraquat + metribuzin or paraquat + metribuzin + alachlor. There were no consistent yield differences among the herbicide treatments during the three-year period.

Fall disking, chiseling or superchiseling followed by none, one or two diskings before planting indicated that method of fall tillage did not affect soybean yield. Yield response from the number of spring diskings was inconsistent. Soybean yields in 1978 averaged about 2.5 bu/acre more following one or two spring diskings than following no spring disking, while average yields were about 4 bu/acre less following one or two diskings in 1979.

A comparison of 12 different herbicide combinations applied in the spring before planting soybeans indicated that mixtures containing cyanazine were less effective for control of annual weeds than were mixtures containing metribuzin in two of three years. However, the mixture of paraquat + cyanazine + alachlor was as effective as were the mixtures containing metribuzin. There were no consistent soybean yield differences among the herbicide treatments.

Yields from soybeans planted without seedbed preparation in soybean stubble after treatment with any one of six different herbicide mixtures applied in the spring before planting were equal to or greater than yields from plots that were chisel plowed in the fall and treated preplant soil incorporated with trifluralin + metribuzin in the spring. Soybeans stubble-planted in 1980 (a dry year) produced higher yields than did any other tillage treatment in any of the four tests conducted.

More than 50% of the Delta of Mississippi is composed of clay (buckshot, gumbo) soils; Sharkey, Alligator and Dowling series (8). Problems associated with managing these soils for soybean production include providing surface and internal drainage and keeping the soils in a condition suitable for planting. The primary objective of preplant tillage is to provide a seedbed to insure a stand.

Pettiet (3) reported that soil acidity and compaction were primary contributors to restricted cotton and soybean plant growth on drought-prone silt loam and silty clay loam soils with a history of low yields.

Deep tillage (subsoiling, chiseling) is a common practice for many cotton producers. Tupper (6) recently reported a two-year average of 8.1 bu/acre soybean yield increase from chisel plowing a silty clay soil in early March before planting soybeans in mid-May. Yield response to tillage of heavy clay soils has been less encouraging. Heatherly (1) was unable to demonstrate soybean yield differences between disking, shallow chiseling (6 inches), deep chiseling (12 inches) or subsoiling (18 to 20 inches) Sharkey clay soil in the spring before planting.

Crop yield increases attributed to deep tillage usually have been in response to increased water intake by the soil profile (6). A parabolic subsoiler and chisel plow to permit deep (16 to 18 inches) and shallow (5 to 10 inches) tillage with reduced energy requirements was designed by Tupper (4, 5). More recently a parabolic super chisel was designed to provide 7- to 14-inch tillage (7). The super chisel was designed to decrease the soil lift problem of the parabolic subsoiler on heavy clay soils, thereby resulting in smaller clods that are more easily broken up for a suitable seedbed.

Four tests were conducted to evaluate soybean and weed response to (1) fall and spring tillage methods with herbicide treatments superimposed, (2) fall tillage method and number of spring diskings followed by a common spring herbicide treatment, (3) conventional fall tillage and several spring-applied preplant herbicides and (4) conventional fall tillage plus a spring preplant, soil-incorporated herbicide treatment compared to several preplant spring-applied treatments with no fall or preplant tillage.

Materials and Methods

The four tests were conducted in the same area of a field of Sharkey clay soil (6.0, 27.6, 66.4 and 1.7% sand, silt, clay and organic matter, respectively, pH 6.1) in 1978, 1979 and 1980. Soybeans had been grown on the area before the tests. The fall treatments were initiated in 1977. Table 1 describes the experimental design, number of replications, treatment composition and abbreviations of treatments for each of the four tests. All treatments except trifluralin + metribuzin were applied with 0.5% (v/v) X-77® surfactant. Tillage, herbicide application, planting and harvest dates by test are listed in Table 2. An experimental unit consisted of four 40-inch-wide rows 50 ft long. Each test was cultivated three or four times during each growing season to a 14-inch band centered on the row.

Disking and herbicide incorporation were accomplished with a 14-ft tandem disk harrow equipped with 18-inch disc blades set to disk 3 to 4 inches deep. The parabolic chisel (or the parabolic super chisel) was operated perpendicular to row direction in Tests 1 and 3 and parallel to the row direction in Tests 2 and 4. Chiseling depth was 4 to 5 inches and the super chiseling depth was 7 to 8 inches. A bed conditioner was used on all plots just ahead of the planter in Tests 1, 2 and 3. Centennial soybeans were planted 1.5 to 2.5 inches deep at a seeding rate of 50 lb/acre, using a planter equipped with double-disk openers.

All herbicides were applied a tank mixes and broadcast in 20 ga water/acre. Percentage weed contro (0 = none, 100 = excellent) an soybean stand (calculated from th number of plants in 10 ft of row from the center two rows of each plot) were determined four week after soybean planting. Weed count by species were made on March 2 just before the spring tillage an herbicide treatments in 1978. Onl the major species were counted i 1979 and 1980. Plots were combine harvested for yield determination and recorded yields were adjuste to 13% moisture. The weight of 10 seed was determined within thre weeks after harvest.

Table 1. Description of tests 1 through 4 conducted on Sharkey clay soil, MAFES Delta Branch, 1978, 1979 and 1980.

Test No.	Experimental Design	No. Reps.	Treatment Composition					
1	Split plot	5	Main plots		Subplots			
			Tillage	Abbr.	Herbicides	Rate-lb/A	Time applied	Abbr.
			Disk - Fall	D-F	Trifluralin + metribuzin	1.25 + 1.5	Fall	TMF[1]
			Disk - Spring	D-S	Paraquat + metribuzin	0.5 + 0.75	Early spring	PMES[2]
			Chisel - Fall	C-F	Paraquat + metribuzin	0.5 + 0.75	Late spring	PMLS[2]
			Chisel - Spring	C-S	Paraquat + metribuzin + alachlor	0.5 + 0.75 + 2.5	Early spring	PMAES[2]
			Super chisel - Fall	SC-F				
			Super chisel - Spring	SC-S	Paraquat + metribuzin + alachlor	0.5 + 0.75 + 2.5	Late spring	PMALS[2]
			Main Plots		Subplots			
2[3]	Split plot	6	Fall tillage	Abbr.	Number spring diskings			
			Disk	D	0			
			Chisel	C	1			
			Super chisel	SC	2			

Continued

Table 1. (Continued)

Test No.	Experimental Design	No. Reps.	Treatment Composition		
			Treatment[2]		
3[4]	Randomized complete block	6	Herbicide	Rate-lb/A	Abbr.
			paraquat + metribuzin	0.5 + 0.75	PM
			paraquat + cyanazine	0.5 + 1.8	PC
			paraquat + metribuzin + alachlor	0.5 + 0.75 + 2.5	PMA
			paraquat + cyanazine + alachlor	0.5 + 1.8 + 2.5	PCA
			glyphosate + metribuzin	1.0 + 0.75	GM
			glyphosate + cyanazine	1.0 + 1.8	GC
			glyphosate + metribuzin + alachlor	1.0 + 0.75 + 2.5	GMA
			glyphosate + cyanazine + alachlor	1.0 + 1.8 + 2.5	GCA
			2,4-D + metribuzin	1.0 + 0.75	2M
			2,4-D + cyanazine	1.0 + 1.8	2C
			2,4-D + metribuzin + alachlor	1.0 + 0.75 + 2.5	2MA
			2,4-D + cyanazine + alachlor	1.0 + 1.8 + 2.5	2CA
			cultivated check	----	U
			Treatment Composition		
4	Randomized complete block	5	Herbicides	Rate lb/A	Abbr.
			paraquat + metribuzin	0.5 + 0.75	PM[2]
			glyphosate + metribuzin	1.0 + 0.75	GM[2]
			2,4-D + metribuzin	1.0 + 0.75	2M[2]
			paraquat + metribuzin + alachlor	0.5 + 0.75 + 2.5	PMA[2]
			glyphosate + metribuzin + alachlor	1.0 + 0.75 + 2.5	GMA[2]
			2,4-D + metribuzin + alachlor	1.0 + 0.75 + 2.5	2MA[2]
			trifluralin + metribuzin	1.0 + 0.50	TM[5]

[1] Applied in the fall and double-disked incorporated - two passes in opposite directions.

[2] Applied preplanting in the spring over-the-top to existing weed cover.

[3] Entire test was treated preplanting with a mixture of paraquat + metribuzin + alachlor at 0.5 + 0.75 + 2.5 lb/A.

[4] Test area was chisel plowed and double-disked in the fall.

[5] Applied preplanting in the spring and double-disked incorporated - two passes in opposite directions. Plot was chiseled plowed in the fall parallel to row direction.

Table 2. Tillage, herbicide application, planting and harvest dates and test number, MAFES Delta Branch, 1978, 1979 and 1980.

Practice	Test number[1/]	Year 1978	Year 1979	Year 1980
		Dates		
Tillage				
Fall (F)	1 thru 4	Nov. 15,1977	Nov. 4, 1978	Nov. 21, 1979
Spring (S)	1	Mar. 23	Apr. 21	Feb. 22
	2	Mar.23, Apr.21	Apr.21, May 15	Apr.8, Apr.22
Herbicide application				
Fall (F)	1 and 4	Nov. 15, 1977	Nov. 4, 1978	Nov. 21, 1979
Early Spring (ES)	1	Mar. 28	Apr. 21	Apr. 8
Late Spring (LS)	1	Apr. 20	May 15	Apr. 25
	2	Apr. 27	May 15	May 8
	3	Apr. 27	May 15	May 9
	4	Apr. 20	May 15	May 9
Planting	1 thru 4	May 19	June 11	June 2
Harvest	1 thru 4	Oct. 31	Oct. 25	Nov. 12

[1/] See Table 1 for test description.

Results

Weed populations. The major winter weeds in all tests were buttercup in 1978, little barley in 1979 and both in 1980 (Table 3). The fall-tilled plots in Test 1 had about 90% fewer weeds in 1978 and 1979 and 37 to 97% fewer weeds in 1980 than did the spring-tilled plots. There were fewer weeds in the fall-disked plots than in the fall-chiseled or fall-super chiseled plots each year in Tests 1 and 2. The treatments in Test 4 that did not receive fall tillage had nearly 10 times more weeds than the treatment that was chisel plowed the previous fall. The counts were made before spring tillage; therefore, the above differences actually compared fall tillage to no tillage from the previous fall to mid-March of each year.

Table 3. Major winter weeds by test number, MAFES Delta Branch, 1978-80.

	Year and major weed			
	1978	1979	1980	
Test number[1/]	Buttercup	Little barley	Buttercup	Little barle
	No./3 ft^2			
Test 1				
Tillage Plot				
DF	1.6	3.2	0.2	0.1
DS	28.8	21.8	6.8	2.4
CF	12.8	9.6	1.6	2.4
CS	82.4	71.2	10.6	8.9
SCF	7.8	8.2	3.2	4.6
SCS	83.8	91.6	12.2	10.8
Test 2				
D	2.1	4.1	0.7	0.3
C	13.5	17.5	5.2	3.6
SC	9.7	11.2	3.5	2.8
Test 3				
Entire area Average	1.1	4.1	0.3	0.4
Test 4				
Fall Chisel Plot	8.7	10.8	2.2	3.2
All other plots	89.1	110.3	14.3	11.2

[1/] See Table 1 for test description.

Data are not shown on an individual plot basis, but the fall-applied treatment of trifluralin + metribuzin in Test 1 controlled the winter weeds each year. The summer weeds were seedling johnsongrass, barnyardgrass, hemp sesbania, prickly sida and morningglory. Johnsongrass increased in severity during the three-year period in plots that were not treated with trifluralin or alachlor. Prostrate knotweed increased in plots in Test 1 where trifluralin + metribuzin was applied in the fall.

All herbicides applied preplant to weeds provided effective control of the winter vegetation. Paraquat combinations gave effective foliage burn down within four to five days while about two weeks were required for the glyphosate or 2, 4-D mixtures to control weeds. 2, 4-D was less effective on little barley than was paraquat or glyphosate.

Test 1 - Fall and spring tillage and herbicides. Summer annual weed control did not differ among tillage treatments in any year (Table 4). Fall-applied trifluralin + metribuzin gave good control but less than that provided by the spring-applied preplant treatment combinations in 1979 and 1980. Paraquat + metribuzin and paraquat + metribuzin + alachlor applied preplant in late spring of 1978 gave better control than did the other treatments. A soybean stand response occurred only in 1980 when the stand after spring chiseling was better than the stands in all other tillage treatments except spring super chiseling. All of the stands in 1980, however, were within the range necessary for maximum yield (2).

A yield difference due to tillage was obtained only in 1979. Both disking treatments and both fall chiseling treatments produced the highest yields. Spring chisel plowing reduced yields.

There were yield differences among the herbicide treatments each year, but the pattern was not consistent. Yields produced on the plots treated with a late-spring application of paraquat + metribuzin + alachlor in 1978 were higher than those produced from plots treated with an early spring application of paraquat + metribuzin or a fall application of trifluralin + metribuzin. Yields from the paraquat +metribuzin treatment applied in late spring were higher than from all other treatments in 1979. The trifluralin + metribuzin treatment applied in the fall resulted in lower yields in 1980 than did the paraquat + metribuzin treatment applied in early spring. However, the extremely low yields (≤8.5 bu/acre) and small yield differences between treatments (≤1.4 bu/acre) in the dry year of 1980 tend to reduce the usefulness of the 1980 data.

Test 2 - Fall tillage and number of spring diskings. No "practical" weed control differences among fall tillage practices or number of spring diskings occurred any year. (Table 5). Soybean plant populations in 1979 were 8 to 12 thousand plants per acre higher in the plots with no spring disking than in plots with two diskings. All stands, however, bordered on the low side for optimum yields (2). Yields from the plots receiving no spring diskings were significantly lowest and highest in 1978 and 1979, respectively. Fall tillage method did not influence yield significantly.

Test 3 - Spring-applied preplant herbicides. All treatments gave better weed control than the cultivated check in 1978, 1979 and 1980 (Table 6). Weed control in 1979 and 1980 was significantly lower from treatments containing cyanazine than from those containing metribuzin, except for the combination of paraquat + cyanazine + alachlor.

There were no consistent soybean-stand differences among the treatments over the three-year period. Stands in 1979 were lower than desired for yield potential. All herbicide treatment means for soybean stand in 1980 were higher than for the cultivated check. The cultivated check also had significantly lower yields in 1978 (3 to 6 bu/acre) and 1980 (2 to 4 bu/acre). Yields in these two years were extremely low.

Table 4. Weed control, soybean stand, seed weight and soybean yield, by tillage and herbicide treatments, Test 1, MAFES Delta Branch, 1978-80.[1/],[2/]

Item	Weed control			Soybean stand			Seed weight			Soybean yield		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
	--------%-------			--1000 plants/Acre--			----------g/100--------			----------bu/Acre--------		
Tillage[2]												
D-F	91 a	96 a	94 a	153 a	58 a	73 bc	10.9 a	14.4 c	13.8 a	18.6 a	44.3 a	8.4 a
D-S	88 a	97 a	93 a	143 a	58 a	76 bc	10.8 a	14.5 bc	14.1 a	20.3 a	44.4 a	9.8 a
C-F	93 a	97 a	93 a	137 a	60 a	66 c	11.3 a	14.7 abc	13.9 a	19.4 a	44.2 a	8.2 a
C-S	94 a	97 a	93 a	145 a	57 a	112 a	10.9 a	15.1 a	14.0 a	19.4 a	39.7 b	8.4 a
SC-F	91 a	93 a	93 a	121 a	52 a	85 bc	11.0 a	14.9 abc	14.2 a	18.5 a	41.4 ab	9.7 a
SC-S	92 a	97 a	94 a	126 a	54 a	100 ab	10.9 a	14.9 ab	13.9 a	18.7 a	40.6 b	8.0 a
Herbicides[2]												
TM-F	88 b	82 b	85 b	138 a	58 a	82 a	17.0 a	14.8 a	13.8 a	18.1 c	41.7 b	7.1 b
PM-ES	88 b	99 a	94 a	134 a	60 a	80 a	11.0 a	14.8 a	13.9 a	18.7 bc	42.6 b	8.5 a
PM-LS	95 a	99 a	98 a	142 a	58 a	95 a	10.9 a	14.7 a	13.9 a	19.3 abc	44.3 a	8.3 ab
PMA-ES	91 b	99 a	94 a	133 a	58 a	85 a	11.0 a	14.6 a	14.2 a	19.6 ab	42.1 b	8.1 ab
PMA-LS	96 a	99 a	96 a	139 a	57 a	85 a	11.0 a	14.8 a	14.2 a	20.0 a	42.0 b	8.3 ab

[1] Means within columns followed by the same letter do not differ at P = 0.05.

[2] See Table 1 for test description and abbreviation meaning and Table 2 for dates.

Table 5. Weed control, soybean stand, seed weight and soybean yield, by fall tillage method and number of spring diskings, Test 2, MAFES Delta Branch, 1978-80.[1/],[2/]

Item	Weed control			Soybean stand			Seed weight			Soybean yield		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
	--------%-------			--1000 plants/Acre--			----------g/100---------			----------bu/Acre-------		
Tillage[2]												
D	91 b	95 a	93 a	129 a	55 a	71 b	10.1 a	15.1 a	13.6 a	18.2 a	42.6 a	8.3 a
C	94 a	57 a	95 a	126 a	53 a	87 a	10.2 a	15.3 a	13.4 a	16.6 a	41.2 a	8.3 a
SC	94 a	95 a	95 a	132 a	57 a	83 a	10.4 a	15.1 a	13.5 a	18.8 a	41.2 a	8.3 a
No. of Diskings												
0	89 b	95 a	92 a	125 a	62 a	73 a	10.1 a	14.9 b	13.7 a	16.3 b	44.1 a	8.7 a
1	95 a	96 a	96 a	131 a	54 b	87 a	10.1 a	15.3 a	13.4 a	18.7 a	40.5 b	8.7 a
2	96 a	95 a	96 a	130 a	50 b	80 a	10.4 a	15.3 a	13.4 a	18.5 a	40.3 b	7.5 a

[1] Means within columns followed by the same letter do not differ at P = 0.05.

[2] See Table 1 for test description and abbreviation meaning and Table 2 for dates.

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Principles of Water Management for Soybean Production

Soybean Production Group, ARS, USDA, Stoneville, Mississippi
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Principles of Water Management for Soybean Production in Mississippi

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Principles of Water Management for Soybean Production in Mississippi

The potential for increasing soybean yields by irrigation in Mississippi is well established. Heatherly (1983) measured a 27 bu/acre increase in yield of soybeans grown on Dubbs silt loam and up to a 37 bu/acre increase in yield of soybeans grown on Sharkey clay during 1980, but that level of yield response to irrigation should not be expected each year. The yield increase was only 1.7 bu/acre and 1 bu/acre on Dubbs silt loam and Sharkey clay, respectively, in 1979, a year of near-ideal rainfall distribution at the test sites. Maximum yield levels were nearly the same, however, in both years.

Non-irrigated yields of Tracy soybeans on Sharkey clay were 53.2 and 15.5 bu/acre in 1979 and 1980, respectively. The year-to-year variation in soybean yields is great, and the variation in response of different soils to irrigation during drought years is high. These conditions cause severe variation in farm income as well as in agribusiness and related-industry income. Sound water-management practices will stabilize soybean yields on a higher level and will reduce the undesirable year-to-year income variability. In this bulletin we discuss the principles involved in soil-plant-water relations, with special emphasis on soybeans. We hope that, by using these relations, farmers and farm advisors will be better able to make wise management decisions to increase and stabilize crop yields and farm income.

Soil-Water Relations

Soil is a complex of varying proportions of four principal components----minerals, nonliving organic matter, air and water. In addition, soil usually contains numerous living organisms, such as bacteria, fungi, algae, protozoa, insects and small animals, which directly or indirectly affect soil structure and plant growth.

On a volumetric basis the mineral particles are the chief components of Mississippi soils. The mineral particles are of various sizes, with the relative mixture of particle-size groups determining the textural classification of each soil. Four mineral fractions, as defined by diameter, are listed in Table 1 along with the percent of each of these particle sizes in three common soil textural classifications.

Depending on the relative contribution of each size class in a particular soil, soils are classified as sands, loams, silts or clays. Most soils fall into various intermediate classes such as sandy loam, silt loam or clay loam.

The least complex soil is a sand, which by definition contains less than 15% silt and clay and is relatively inert chemically. Sandy soils form relatively simple capillary systems with a major portion of their volume made up of large pore spaces, and this ensures good drainage and aeration. However, because

Table 1. Classification of soil particles according to the International Society of Soil Science and the mechanical analysis of three soils.

Fraction	Particle Diameter	Soil Texture		
		Sandy Loam	Loam	Heavy Clay
	millimeter		%	
Course sand	2.0 - 0.2	66.6	27.1	0.9
Fine sand	0.20 - 0.02	17.8	30.3	7.1
Silt	0.02 - 0.002	5.6	20.2	21.4
Clay	Smaller than .002	8.5	19.3	65.8

of these large pores and the subsequent rapid drainage following addition of water, these soils hold very little water that is available for use by plants.

Clay soils are at the other textural extreme with reference to particle size and complexity, because they contain a minimum of 40% clay. The clay particles usually are aggregated in complex granules and are plate-like in shape. Because of their shape and small size, these aggregates have a much greater surface area than do cubes or spheres of similar volume. The extensive surface area of the clay particles enables clay soils to hold more water and minerals than do sandy soils. For example, a cubic sand grain 1 mm on each edge has a surface area of only 6 mm^2, but, if it is broken into clay-sized particles of 0.001 mm on each edge, the resulting total surface area is 6000 mm^2. It has been calculated that the surface area available to bind water ranges from less than 1000 cm^2/g in coarse sands to more than 1,000,000 cm^2/g in clays. Thus, the relatively small size of the particles in the clay fraction largely controls both the chemical and physical properties of soils.

Loam soils contain more or less equal amounts of sand, silt and clay; therefore, they have properties that are intermediate between those of clay and sand. Such soils are considered to be the most favorable for crop production, because they hold more readily-available water than either sand or clay, and have more nutrients than sand. They are also better aerated and easier to work than clay.

About half of the soil volume is usually occupied by air and water. For practical purposes, this pore space may be divided into two major classes—(1) large pores, which do not hold water against gravitational forces and (2) small pores, which hold water that will not drain due to gravity. Large pores drain freely and quickly after rain or irrigation and are normally filled with air The small pores contain water that remains after most free drainage from large pores is complete. Part but not all, of this water is available to plants. Heavy soils (those high in clay content and total pore space) allow only slow air and water adjustment because of the large total surface area of the particles This surface area holds water by surface tension, so it resists the force of gravity.

In sandy soils, the large pores predominate, and this results in better drainage and aeration and lower water-holding capacity than in clay soils, which have a large proportion of small pores (Figure 1). Ideal agricultural soils have about equal volumes of small and large pores. Such soils have enough large pores to permit adequate and reasonably rapid water infiltration, drainage and aeration and enough small pores to provide adequate water-holding capacity to support crop growth.

Water Retention by Soil

As water is removed from the soil during drying, air replaces the water in the pore space (Figure 1). As a result, air-water interfaces develop and form curved water surfaces between adjacent particles of soil. The surface tension acting in these curved interfaces counterbalances the forces of water removal caused by either gravity, evaporation or plant roots. This is one mechanism by which water is retained in the soil.

In shrinking soils such as Sharkey or Houston clay, another mechanism is involved in retaining water in the soil. As water is removed, the soil particles are brought closer together by the characteristic shrinkage of spaces between the particles. These particles carry a negative surface charge and act to repel one another. As the soil particles are

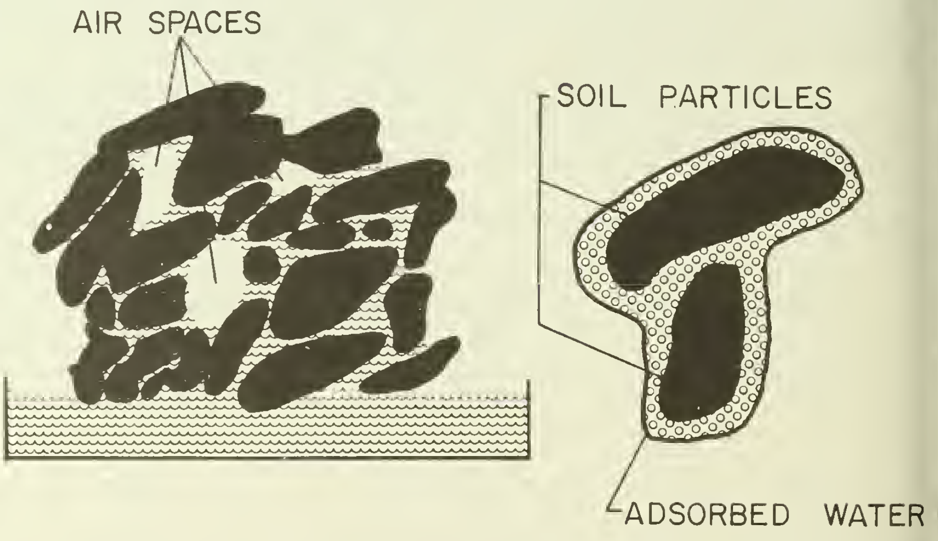

Figure 1. (Left) Diagram of soil particles with saturated zone at bottom. Drainage has allowed air to enter larger pore spaces near surface.

(Right) Enlarged sketch of soil particles after drainage is complete. The adsorbed water near the soil surface is partially available for plant use.

brought closer together by the removal of water, the repulsive forces become greater. The shrinkage and associated repulsive forces of the clay particles balance the tension caused by drying.

In some soils, high salt concentrations also decrease the availability of water to plants, thereby providing a third mechanism by which water is retained in soils, thus affecting the availability of water to plants. However, this is not an important mechanism of water retention in Delta soils, nor in most other Mississippi soils.

Water absorbed by dry soils is held very tightly by the mechanisms described above. Absorbed water is accompanied by an equally important force---the attraction of water molecules to each other. As soil water becomes more plentiful, water molecules are attracted to other water molecules and produce films around the soil particles. As these water films increase in thickness, the outer surface of the water film is influenced less by the soil surfaces and becomes subject to removal by gravitational and evaporational forces. Therefore, when the soil is near saturation, it is very easy to remove the initial increments of water. However, as the soil moisture content is lowered, the water films become thinner and the force necessary to remove subsequent increments becomes progressively greater.

This dynamic manner in which water is held in soil is especially important, because it affects many aspects of management for crop production. For example, it affects the principal factors related to drainage after a saturating rain or irrigation, it affects the concept of field capacity (the moisture content of soil following removal of water by gravity), and it affects the availability of soil water to plants.

In addition to gravitational flow through large pores, as has already been mentioned, water moves at slower rates in the small pores due to capillary action. Gradients, or differences in soil-water content from one point to another, may exist within a given volume of soil due to differences in water supply and water use. A root may extract significant quantities of small-pore water from a particular region of the soil. The area in the immediate vicinity of the root may become drier during a period of rapid use, but it will gain water from the surrounding soil during the night or during a period of low water use. The distance that significant amounts of water can move by capillary action is rather low. The rate at which it moves depends on the gradient or differences in moisture content of the soil and soil texture. More water can move by capillary action at high soil-moisture levels than under drier conditions regardless of the soil moisture gradient.

The energy concept of soil retention

Space here does not permit a discussion of the details of measuring soil water-retention characteristics. Briefly, however, a force applied to soil will expel water from the soil, and the water expelled at a particular force can be measured. In practice, this is accomplished by beginning with a saturated soil and applying a small force, usually about equal to that of gravity, and a certain amount of water will be expelled, depending on the retention ability of the particular soil. The soil is then said to be at or near field capacity. The force generally used to accomplish this effect is about 0.3 bar of pressure or suction. (A tensiometer in equilibrium with a saturated soil will read about zero. At field capacity the tensiometer will read about 0.3 bar or 30 centibars.) One bar is equivalent to about one atmosphere of pressure (14.7 lbs/inch^2 or 29.5 inches of mercury under standard conditions). By adding additional pressure (force) to the soil sample, additional water is expelled. This process can be continued until essentially all of the water available to plants is removed. Data from such treatments can be used to determine the amount of water available in a particular soil at different pressures or tensions. Additionally, one can estimate the relative availability of water at any soil moisture content. Table 2 shows typical soil moisture retention relationships of selected soils.

Some investigators have grown different plant species until they reached the permanent wilting point (that point at which a plant will not recover from wilt until water is added to soil). They found this to occur at about 15 bars of soil-water tension. The water content at 15 bars may be subtracted from the water content at field capacity to determine the amount of water available to plants between field capacity and the permanent wilting point. Sharkey clay has about 11%, and Dubbs silt loam has about 20% plant-available water. In practice, however, if irrigation facilities are available, a crop should not be allowed to become so dry that it becomes permanently wilted. A more practical definition of plant-available water might be the water available between field capacity or 0.3 and 1.0 bar. The soil moisture available between 1.0 and 15.0 bars tension apparently requires the plant to be under tensions high enough that plant injury occurs during the water extraction process. Therefore, we prefer to call the soil water held between 0.3 and 1.0 bar

Table 2. Volumetric water content of soils equilibrated at different pressures.

Soil Water tension	Estimated relationships	Soil Type		
		Sharkey clay*	Dubbs silt loam*	Bosket very fine sandy loam
bars		%		
0.3	Field capacity	36.8	27.5	24.2
0.7	Limit of Tensiometers	34.1	21.0	16.1
1.0		32.8	18.4	13.6
3.0		30.0	13.0	8.9
5.0		28.4	11.2	8.0
10.0		27.0	9.0	7.3
15.0	Permanent Wilting Point	26.0	8.0	6.9

*Data from Heatherly, L. G., and W. J. Russell, Field Crops Research 2:135-143. 1979.

readily available plant water. The amount of *readily available plant water*, found by subtracting the percent water at 1.0 bar from the percent water at 0.3 bar (36.8% - 32.8%) is 4% for Sharkey clay (Table 2). By multiplying 4% by 50 inches of soil depth (a reasonable estimate of effective rooting depth), one can see that Sharkey clay has only 2 inches of *readily available plant water*. The 4% estimate calculated above, however, may be conservative because field capacity in clay soils probably occurs at tensions near 0.1 bar; however, the 0.3 bar is a more reasonable estimate of water tension at field capacity in most coarser-textured soils.

Plant Responses to Water Deficit

The leaves of plants are ideally suited for the exchange of gases (carbon dioxide, water vapor, etc.) and the trapping of energy from the sun. The surfaces of leaves are coated with a waxy substance called cutin, which protects the leaves from excessive water loss. This waxy surface is interspersed with literally millions of tiny pores, called stomata. These stomata are formed by specialized cells that are capable of expanding and contracting, thereby causing opening or closing of the pores. This mechanism allows the plant to control the movement of air and moisture to and from the interior of the leaf, depending on the plant's internal water condition and the external environment (temperature, relative humidity, etc.). Generally, the stomata are open during the day and closed during the night. If the environment around the plant is such that the plant's internal water status becomes too stressed, however, the stomata will close to limit water loss.

Under conditions of adequate water, the stomata will open in the early morning in response to the sun's rays. Water vapor is lost through the open stomata of the leaf by the evaporation of water from the moist interior cell surfaces, and carbon dioxide from the atmosphere diffuses into internal areas of the leaves through the same stomata. Once inside the leaf, carbon dioxide is adsorbed onto the wet cell surfaces. It then diffuses into the cells where it is converted (via photosynthesis) into sugar, the primary energy source that drives all plant growth and development. Also, sugar ultimately provides the building blocks for structural materials (cell walls, proteins, chlorophyll, lipids, etc).

As evaporation from the leaf continues, the loss of water creates a tension in the cells. This tension pulls water from the adjacent vascular system, which transmits the tension down the stem to the root system. As the tension in the root system is increased, water from the surrounding soil is absorbed by the root. The water tension inside the root competes with the soil particles for available water. If the soil water is in relatively good supply, the root moisture deficit need not be very low to pull the water away from the soil; however, if the soil-water supply is relatively low and the water film on soil particles is thinner, the soil particles hold the available water more tightly. In cases of low water supply, the root tension must be fairly high to remove the limited water from the soil.

The moisture tension in a plant is therefore controlled by (1) the soil moisture supply and (2) the evaporative demand of the atmosphere. Figure 2 illustrates how these two factors interact to cause wilting. Under wet soil conditions (36% soil water), transpiration (loss of water from plant leaves to the atmosphere) was limited by the environmental conditions until water loss exceeded about 0.28 inch/day. At 25% soil moisture, however, the plants were able to use only about 0.06 inch/day because of the limited soil-water supply. If the atmospheric demand had been greater, the plants would have wilted. On a cloudy, overcast day, the evaporative demand was low; and the plants did not wilt, even in this relatively dry soil. Thus, differences in atmospheric demand interact with differences in the soil water supply to cause varying patterns of plant response.

In sandy soils, the portion of the plant-available water available at low soil moisture tensions increases as the soils become drier, but relatively little reserve moisture is available. An examination of Table 2 shows that Bosket very fine sandy loam has about 61% (5.3 inches in the surface 50 inches) of its plant-available water between field capacity and 1.0 bar, while Sharkey clay has only 37% (2.0 inches in the surface 50 inches) of its plant-available water in the *readily available soil moisture* range.

The available soil moisture may be expressed as a continuous curve, with decreasing quantities of water remaining in the soil after extraction at increasing tensions, and one may question whether the comparison at 1.0 bar is justified. We have found that controlling soil moisture so that it never gets above 1.0 bar tension produces higher yields than if the soil is allowed to become drier before irrigation is applied. Therefore, the value of 1.0 bar appears to have some validity.

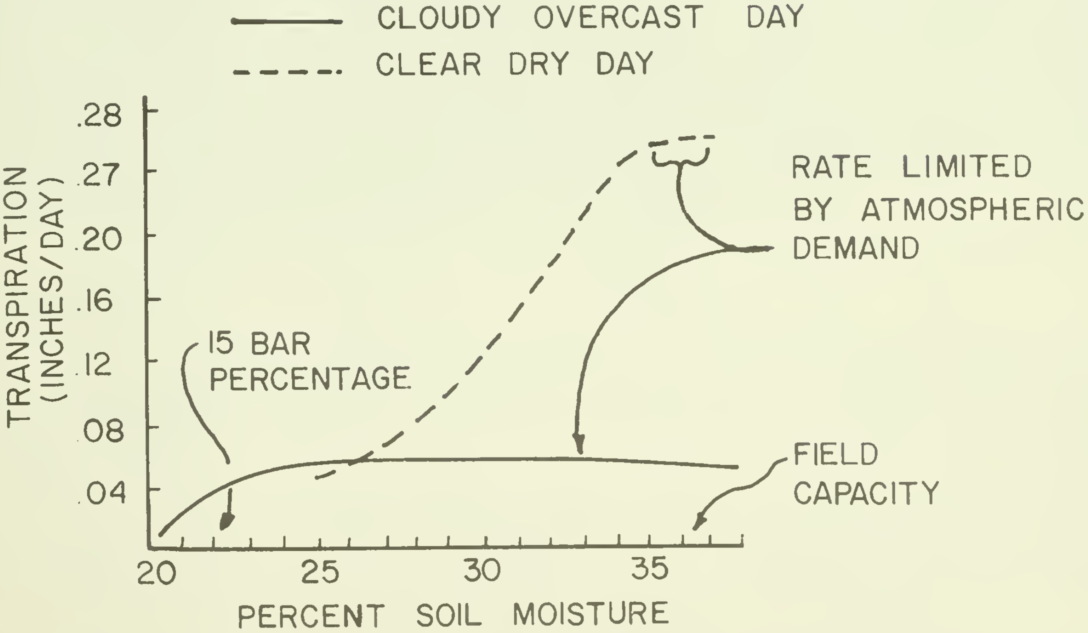

Figure 2. The effect of decreasing soil water content on rate of transpiration during days of high and low potential transpiration (after Denmead and Shaw).

Drought Stress

The moisture status of leaves is a function of both soil water supply and evaporative demand of the atmosphere. In the field, significant water deficits develop even in well-watered plants. As water evaporates from the leaves, the tensions that develop increase the rate of water uptake. If roots cannot absorb water rapidly enough, the leaf water status will come under increasingly higher tensions. On sunny days the leaves of soybean plants normally will reach tensions of 12 or 14 bars (equilivant to 175 to 200 pounds/inch^2).

Figure 3 illustrates a typical daily time course of leaf water-tension values. Near midday, clouds often develop and provide brief periods of lower solar radiation which reduces leaf water tensions and plant stress. As darkness approaches, the rate of evaporation decreases and leaf tension becomes less as water from the soil is transported from the absorbing roots to the leaves. In well-watered soils the leaf water tension will return to values near zero very quickly after darkness, but in drier soils the leaf water tension will recover much more slowly and will very gradually approach the soil-water potential. Leaf water tension is at its lowest point just before dawn, and the difference between these values and the soil-water potential values at this time is directly proportional to the dryness of the soil.

Leaf growth is very sensitive to leaf water tensions (Figure 4). As the leaf water tension becomes greater than 4 bars, the rate of leaf expansion nearly ceases. By the time the leaves reach values as high as 12 bars, growth is completely stopped. Boyer (1968) found that leaf enlargement was reduced to 25% of that of the well-watered controls by a tension of 4 bars. This level of tension normally occurs in the field by 9 or 10 o'clock in the morning; therefore, daytime leaf growth is greatly reduced even on well-watered soils. If the plants are exposed to reasonably good moisture conditions, they will recover overnight and growth will proceed. Nearly all leaf expansion

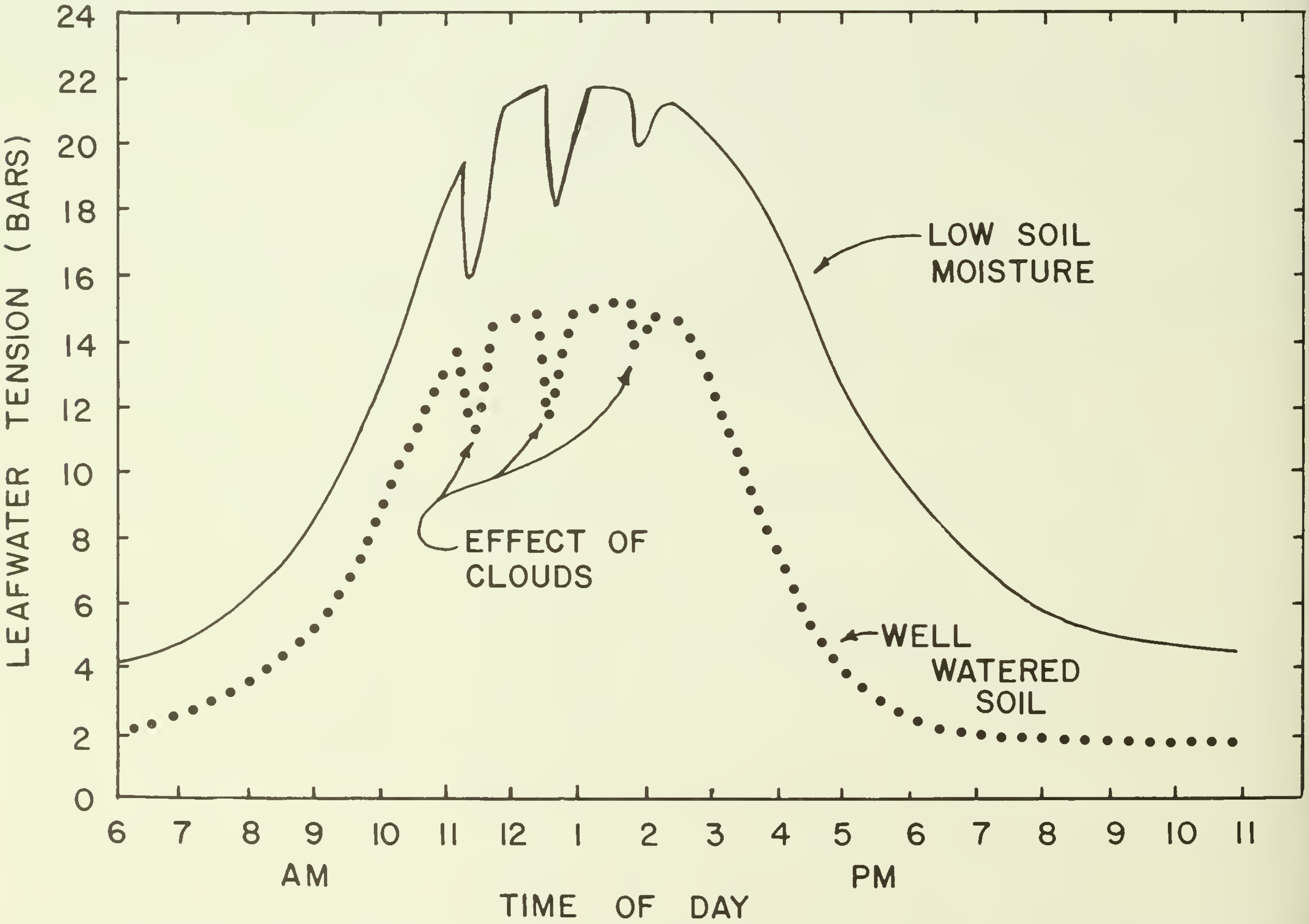

Figure 3. Typical soybean leaf water tensions during the course of a day on well-watered and relatively dry soils.

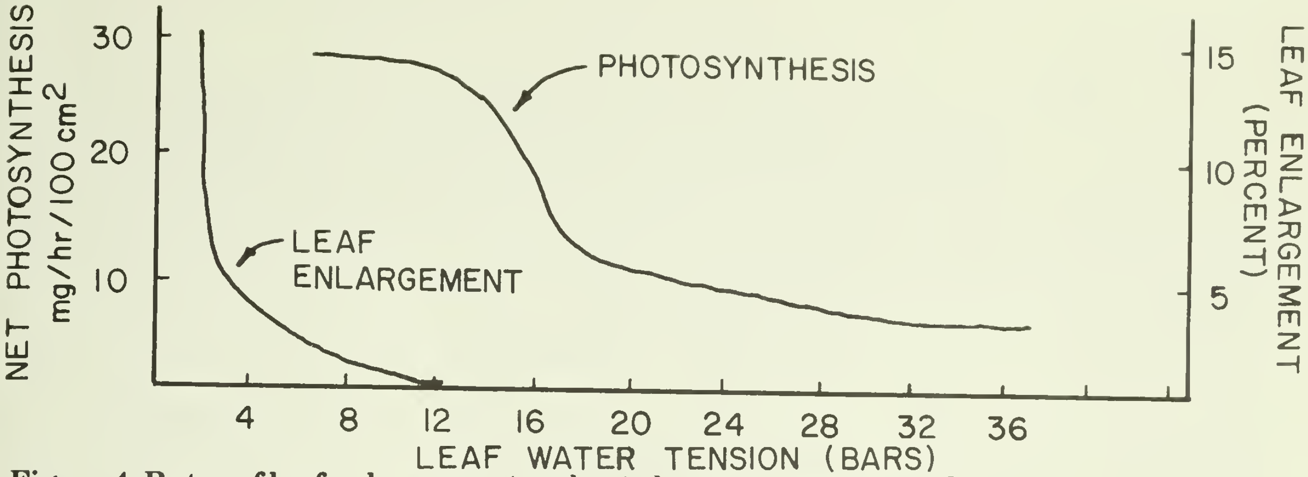

Figure 4. Rates of leaf enlargement and net photosynthesis of soybeans at various leaf-water potentials (after Boyer).

and stem elongation occurs at night when water conditions in the plant are most favorable, and there is negligible loss of water from the leaves to the atmosphere.

If, however, the soil is relatively dry, the daytime leaf water tension may reach values of 18 to 22 bars. The overnight recovery from such high tension is slower and less complete. If such steadily increasing tensions are allowed to reoccur for several consecutive days, non-reversible damage occurs. The extent of damage depends on the longevity of the drought, while the type of damage to the plant depends on the growth stage. If prolonged moisture stress occurs during the vegetative stage, the leaves in the terminals of the main stems and branches of stressed plants will essentially stop growing and turn dark green. If and when the stress is relieved, these leaves will once again start growing, but they will not reach the size of the leaves that developed during non-stress conditions. Internode length is affected in essentially the same manner; therefore, both leaf area and plant height will be reduced by stress.

Photosynthesis and Dry Matter Accumulation

The photosynthetic process is less sensitive to moisture stress than is leaf expansion or stem growth. Soybean leaves continue to produce dry matter with no apparent reduction in rate until they reach about 12 bars of tension (equivalent to 176 lbs/inch^2). They continue producing at about 30% of their maximum rate even after they reach tensions as high as 20 bars (equivalent to 280 lbs/inch^2). In addition to a direct reduction in growth rate that occurs due to lower dry matter production per leaf (photosynthesis), drought also affects the time that leaves are functional. Thus, a result of severe drought stress is the early or premature death of the leaves, with lower leaves dying first. This results in an irreversible loss of capacity of the plant to intercept light and produce dry matter.

Flowering and Seed Set

Flowering also may be delayed by drought stress. Drought during early flowering causes abortion of flowers and reduces numbers of pods set, but additional flowers may be produced if the stress is relieved. Drought stress that occurs during late blooming causes the loss of young pods and an irreversible loss in yield. Drought stress during the beginning of podfill can result in fewer seed per pod, while stress during mid- to late-pod filling results in smaller seed and may hasten apparent maturity by causing leaves to drop early. Overall, drought stress severe enough to reduce yield does so mainly by reducing numbers of seed/acre.

In an experiment to evaluate the susceptibility of soybeans to stress at different stages of development, we found about equal sensitivity at all reproductive growth stages. There was a nearly linear loss in yield (expressed as percent of the non-stressed plots) vs numbers of days of wilting. Yield was reduced from 100% at zero days of wilting to about 60% of that of the well-watered control by 14 days of continuous wilting (Figure 5). Yield reduction continued, but at a decreased rate, when the plants were exposed to additional wilting conditions after the initial 14-day period.

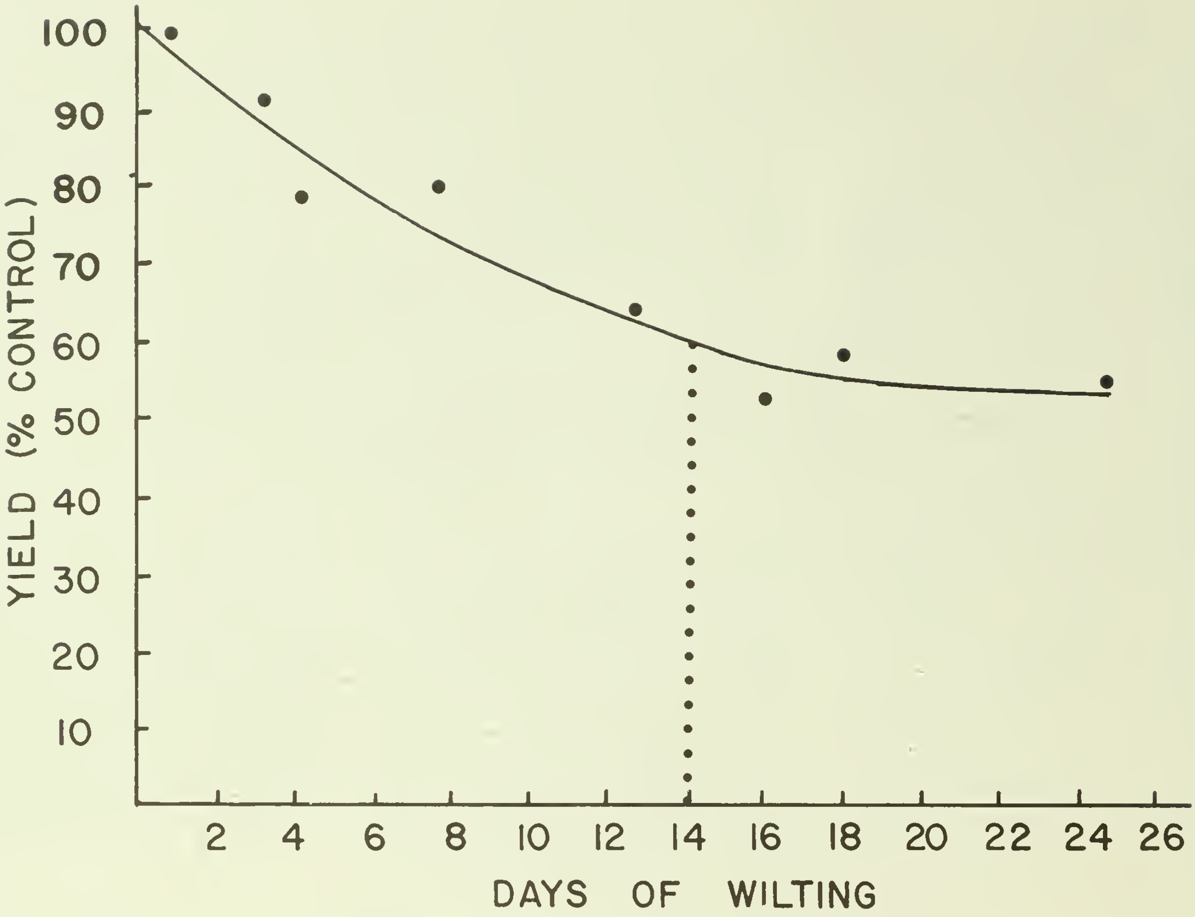

Figure 5. Effect of days of wilting on soybean yields.

We conclude, then, that the key to water management for soybeans is to initiate irrigation at or near bloom and to continue on a consistent and timely basis until seed are fully developed. This allows all phases of soybean reproductive development to occur in well-watered conditions. If water is applied during early reproductive development (bloom, early podset) but is withheld thereafter, the excellent pod load established by the early watering cannot be maintained by the plant. Therefore, numbers of seed per pod and/or seed size will be reduced, and potential yield will not be realized. On the other hand, if irrigation is delayed until later stages of reproductive development (late podset or beginning of seed filling), the potential pod load may not have been realized, and potential yield will not be achieved. In this case, seed per pod and seed size will both be near the maximum, but yield will be reduced because of lower-than-maximum numbers of pods. If drought occurs early or if *readily available soil water* is lacking due to double cropping, it is beneficial to irrigate to get a uniform stand and to develop plants of sufficient vegetative stature to produce a good seed crop.

Drought stress at any time results in reduced growth and reduced yield. Heatherly (1983) found that soil-water management throughout the season produced the highest crop yield. Full-season irrigation requires detection of moisture stress by frequent and routine soil-moisture monitoring and the application of irrigation or rain before serious stress develops. Recent work in Israel with trickle irrigation has shown that watering cotton and vegetable crops throughout the growing season has resulted in the highest yield response. Proper management of trickle irrigation requires frequent application of very small amounts of water. This degree of management intensity is not feasible under our conditions and with a relatively low-value crop, but the principle of frequent and small applications of water should provide a meaningful lesson.

Adaptation

It is widely thought that crops adapt to drought stress and become capable of withstanding drought. There is little evidence to support this view, when it is considered on the basis of producing an economic yield. The limited adaptation that does occur only increases the plant's ability to survive. Under prolonged drought, the plants increase their sugar concentration in cells, effectively allowing the plants to develop greater tensions. Therefore, the crop will be slightly more effective in extracting soil water and retaining water against atmospheric demand. This process, however, is one that occurs primarily as a survival mechanism, and a crop found to respond in this manner already has been damaged and will not reach its yield potential. Upon rewatering, these plants will lose the adaptation to drought within about a week, yet will still show rather serious yield reductions because of the effects on yield components described above. Each time this process is repeated, further reductions in yield occur, thus greatly reducing the value of the crop.

Under management that is directed at maintaining excellent growing conditions (irrigation when the soil-water tension reaches 1 bar at one foot depth), there is some concern about producing excessive vegetative growth, which might induce some lodging. This problem is not of serious concern for soybeans grown on clay soils; however, it may be avoided on coarser textured soils by reducing seeding rates to lower plant populations.

Summary

Soil texture has a profound effect on the manner in which water is retained in the soil. Coarse-textured, sandy soils have an abundance of large pores that readily fill with water but drain rapidly due to gravity. Relatively little water is retained in the small pores of sandy soils. Fine-textured, clay soils have a large percentage of their total volume occupied by very small pores. These pores exchange gas and water slowly. The water in small pores is bound to the clay particles and resists extraction by gravity and by plants. The water in small pores is available to plants only when the tension in the plants exceeds the tension with which the soil binds the water. Therefore, clay soils hold a large amount of water, but that water is bound tightly by the soil particles, and only a small portion is available to plants at rates required for good crop production. Therefore, maximum yields on clay soils require frequent applications of water. Plants are very sensitive to water availability.

In marginal water supply vs. atmospheric evaporative-demand conditions, the stomata open and close to maintain a turgid, functional leaf in-so-far as possible. When the water supply-demand conditions become too far out of balance, the plant loses its turgidity and wilts. Several physiological processes are quite sensitive to water stress and respond to tension before wilting occurs. For example, leaf and stem growth are the developmental processes most sensitive to drought stress. Drought will quickly reduce leaf and stem growth, but flowering, seed set, seed growth and photosynthesis also are affected by water deficits. Yield is often lowered by reducing numbers of seed produced per acre due to drought during the flowering and seed-set period of development. Droughts occurring late in the season often result in reduced seed size. This is caused by lower photosynthetic rates and premature leaf death.

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